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NOTE ON TWO CASES OF WELL-MARKED SUPRASTERNAL BONES.

By A. Francis Dixon, *Trinity College, Dublin.*

During the last few years I have examined a large number of subjects for the presence of suprasternal bones, and as detailed illustrations of them have, as far as I am aware, not been published, it seems worth while to reproduce X-ray pictures of two cases in which they were well developed.

These pictures were kindly made for me by my friend Dr W. G. Harvey, University Demonstrator in Röntgen Photography in Trinity College. They illustrate very beautifully the form, position, structure, and relationships of the ossicles.

Fig. A represents the condition found in a young adult man. The suprasternal bones are conical in form, well developed, and almost symmetrically disposed. The wide base of each articulates by a diarthrodial joint with a special facet on the superior border of the manubrium sterni close to the medial edge of the clavicular notch. At their bases the ossicles almost meet in the median plane, but superiorly their apices are separated by a distinct V-shaped interval. The capsular ligaments which unite the ossicles to the manubrium sterni are loose enough to permit considerable movement at the articulations.

Fig. B is taken from an adult woman. The suprasternal bones are somewhat pea-shaped, and are placed close against the median plane. As in the first specimen, they are connected with the superior border of the manubrium sterni by diarthrodial joints; and further, a diarthrodial joint is present in the median plane where the right and left ossicles are in contact with one another. In both cases it will be noticed that the architecture of the suprasternal bones resembles that of the sternum.

Each suprasternal ossicle is tied down to the sternum by a well-defined fibrous capsule which is specially thickened on its anterior aspect to form a rounded cord-like ligament. The anterior surfaces of the ossicles are connected by a fibrous band, the upper margin of which is continuous with

Fig. A.

Fig. B.

the interclavicular ligament. Laterally each is connected to the clavicle by a fibrous cord the lower and lateral edge of which is continuous with the sterno-clavicular ligament.[1]

It should be mentioned that the suprasternal bones are not directly connected with the fibro-cartilaginous articular disc, and that the joints which they form with the sternum are distinct, and isolated from the sterno-clavicular articulations.

In each case the X-ray pictures show that the suprasternal bones are

FIG. C.—Suprasternal bones and the ligaments connected with them. From an adult female subject; same specimen as fig. B. Drawn by Mr J. T. Murray.

much larger than a dissection of them and of their ligaments would lead us to believe. The greater part of the surface of each ossicle is covered by the strong cord-like ligaments which pass to the manubrium sterni, the clavicle, and to the ossicle of the opposite side. (Compare figs. B and C.)

Note.—The X-ray figures were exhibited at the Exhibition of the International Medical Congress in London, summer 1913.

[1] Somewhat similar ligaments have been figured by Thomas Carwardine, *Jour. of Anat. and Phys.*, vol. xxvii., 1893, p. 232.

THE DEVELOPMENT OF THE LOBUS QUADRATUS OF THE LIVER, WITH SPECIAL REFERENCE TO AN UNUSUAL ANOMALY OF THIS LOBE IN THE ADULT.

By Professor PETER THOMPSON, *Birmingham.*

IN view of the interest associated with the modifications which the lobes and the fissures of the human liver have undergone during the process of evolution, any specimen which would appear to throw light on the problem deserves the closest examination. In the past much of our knowledge has been derived from a study of the anatomy of the organ in the fœtus, in man's nearest allies—the anthropoid apes, and in other more generalised forms. In recent years, too, much has been done to trace the phylogenetic and ontogenetic development of the lobes and fissures of the liver in human and other embryos, and in the well-known publications of A. Thomson (1), Mall (2), Ruge (3), Rex (4), Bradley (5), de Burlet (6), and others, not only has the development of the lobes and fissures received attention, but also the arrangement of the vascular system within the organ during its early stages of growth, and in the adult.

Apart from de Burlet's publication I have not, however, been able to find any special reference to the development of the lobus quadratus in the human liver, or to its influence on the fossæ on either side of it. It is to these points more particularly that I wish to direct attention, since it is generally held that the lobus quadratus is merely a quadrilateral area of the visceral surface of the liver, bounded by certain fossæ, and of no comparative morphological interest. It was the apparent absence of this lobe in a specimen obtained from the practical anatomy rooms in this University that suggested an investigation as to when and how it appeared in the normal human liver. As a matter of fact, a small tubercle was present in this liver, which, after comparison with the models of the liver from early embryos, was clearly the representative of the lobus quadratus. It will be convenient if this specimen be briefly described before proceeding with the account of the models which have been made to explain the anomaly.

The specimen was obtained from a male subject, aged 60 years, the cause of death being certified as bronchitis. On the visceral surface of the organ (fig. 1), the division into right and left lobes is indicated ventrally by a deep cleft occupied by the gall-bladder. The lobus Spigelii and the pro-

cessus caudatus are well marked and distinct, and it is noteworthy that the former is larger than usual and has a form closely resembling that found in a 11·25 mm. embryo. Of the fissures four are clearly defined: (1) the right lateral, (2) the fissure limiting ventrally the processus pyramidalis, (3) the fissure partly limiting the processus caudatus, and (4) a deep depression—the fossa for the ductus venosus. On pulling the gall-bladder—the fundus and body of which were entirely surrounded by peritoneum and quite free—downwards and backwards from the fossa (fig. 2),

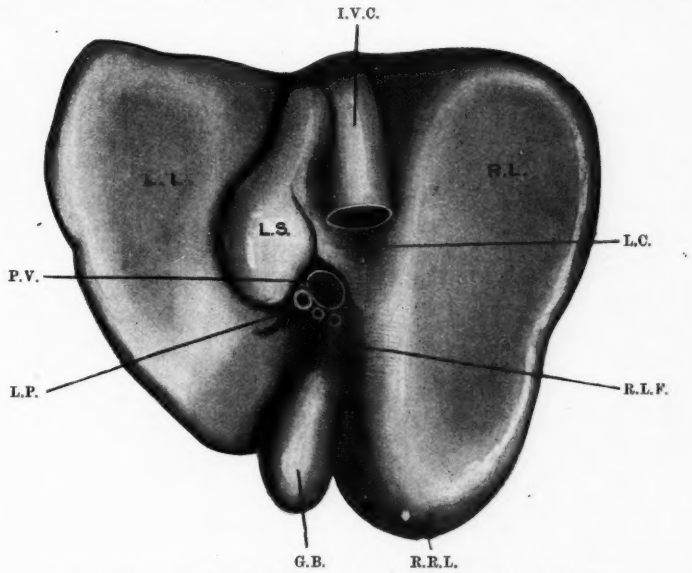

FIG. 1.—Visceral aspect of adult liver with rudimentary lobus quadratus.

three structures stand out clearly: the round ligament, a small rounded tubercle which, as already stated, represents the lobus quadratus, and a connecting ridge of tissue, partly hepatic and partly fibrous, joining the tubercle to the under surface of the left lobe. The significance of this connecting ridge will become evident after an examination of the model of the liver from a 11·25 mm. embryo. In fig. 3 a view of the liver from the front is shown, with the relations to one another of gall-bladder, ligamentum teres, rudimentary quadrate lobe, and an area designated the "uncovered area." This uncovered area is a portion of the right lobe, which would, one imagines, have been subjacent to the lobus quadratus, had the latter been of the normal size.

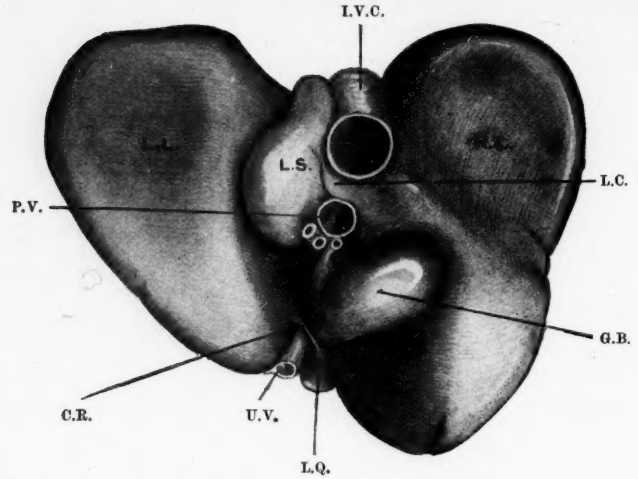

FIG. 2.—The same, with gall-bladder pulled away to show the ligamentum teres and rudimentary quadrate lobe.

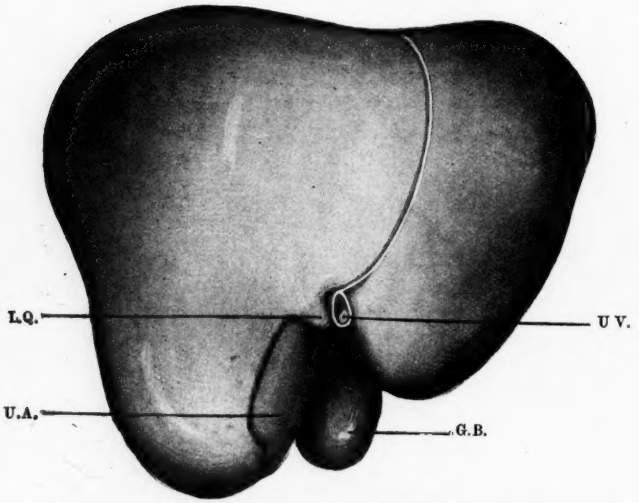

FIG. 3.—The same, seen from the front.

In the generalised mammalian liver we recognise six lobes (Flower) (7), R. central, L. central, R. lateral, L. lateral, L. Spigelii, and L. caudatus, the line of the ligamentum teres being taken in this case as the median plane. The right central lobe lies between the median plane and the right lateral fissure, and the gall-bladder is placed usually somewhere near the middle of the lobe on the visceral surface. It can therefore be said to be composed of two parts: (1) between the fossa for the gall-bladder and the right lateral fissure, and (2) between the fossa for the gall-bladder and the median plane. On referring to fig. 1 it will be seen that in the specimen just described the first part is present and appears quite normal, whilst the second part (fig. 2) is rudimentary and appears as the small rounded tubercle previously referred to.[1] If this interpretation be correct, then it would appear that one portion of the right central lobe, the median (L. quadratus), exhibits an interesting malformation, and it is one of the objects of this paper to show that it is, in fact, in a condition of arrested development. The condition, permanent in this specimen, is transitory in embryos in the fifth week. Moreover, it somewhat resembles the arrangement of parts in the adult pig, in which the quadrate lobule is a relatively small process, and the rest of the right lateral lobe is of large size.

Anomalies in the lobulation of the liver are by no means uncommon, and variations in the size and form of the lobus quadratus have been described by several observers. In Rolleston's (8) first case, in which the right lobe was small and the left lobe large, the lobus quadratus was three times the size of the remainder of the under surface of the right lobe. In a second specimen the gall-bladder was placed below the lobus quadratus instead of being on its right side, whilst in a third case described by him the lobus was rudimentary, being represented by a small strip of liver tissue only. In a case described by Barclay-Smith (9) the gall-bladder was abnormally placed and the lobus quadratus appeared in its usual position, whilst Hochstetter (10) has described and figured two cases of abnormally placed gall-bladder with absence of the lobus quadratus. Ruge's admirable papers (3) are well known, and in them will be found an enormous number of observations referring to abnormalities of the lobes and fissures of the human liver. In one of them he has dealt specially with the abnormal folds, fissures, and accessory lobules found in connexion with the lobus pre-portalis (L. quadratus), but there does not appear to be any case at all resembling the one described above.

It will be convenient to describe next the three wax models of the

[1] That the fossa (or fissure) separating these two parts in fig. 2 is the fossa vesicæ felleæ is shown by the attachment of the neck of the gall-bladder by a mesentery to its floor.

human liver figured in the text, of which the following details may be noted:—

Specimen I. Greatest length of embryo 7 mm. Sections 10 μ. Magnification of model 50 times.

„ II. Greatest length of embryo 11·25 mm. Sections 10 μ. Magnification of model 37·5 times.

„ III. Greatest length of embryo 16 mm. Sections 10 μ. Magnification of model 50 times.

In recent years several models have been made and illustrations published to show the form of the liver in the human embryo. Of these mention should be made particularly of the reconstructions by Bromann (11), Mall (2), and H. M. de Burlet (6). In his monograph on *The Bursa Omentalis*, published in 1904, Bromann shows figures of models of the liver of four human embryos measuring 3 mm., 5 mm., 8 mm., and 11·7 mm. respectively. Mall, in his paper on the *Structural Unit of the Liver* (1906), gives a detailed account of the early development of the liver, and shows illustrations of models of the organ from embryos 24 mm. long, 17½ mm. long, and a second one 24 mm. long. The growth of the quadrate lobe, however, is not specially traced in either of these publications, attention being directed to other matters. The material for de Burlet's paper on "Die äusseren Formverhältnisse der Leber beim menschlichen Embryo" (1910) comprises five specimens, of the following lengths respectively (1) 4·75 mm.; (2) 10 mm.; (3) 18 mm.; (4) 23 mm.; and (5) 32 mm. It will thus be seen that the models figured in the present paper fall into the intervals between the first three of the last-named series, and as the subsequent description will show, it is in embryos about 33 days old, *i.e.* 11·25 mm. long, that the interval on the visceral surface between the gall-bladder and the vena umbilicalis becomes occupied by a mass of liver cells, forming a small rounded tubercle, the forerunner of the lobus quadratus.

Specimen I.

Upon the ventral aspect (fig. 4) is an extensive area, where the liver and septum transversum are united, corresponding to the interval between the two layers of the ligamentum falciforme, which are continuous below round the vena umbilicalis. To the right is the mass of tissue (mesenchyme) in which lies the gall-bladder. This tissue is continuous on the one side with the omentum minus (fig. 5), and on the other with the ligamentum falciforme, the whole forming the so-called ventral mesentery.[1]

[1] In this connexion it is interesting to note that, as Professor A. Keith kindly pointed out to me, the gall-bladder in the cassowary (*Casuarius bennetti*) is situated in the omentum minus.

The right lobe is larger than the left, and the quadrate lobe is not present. From the upper border a large vein emerges, the ductus venosus Arantii,

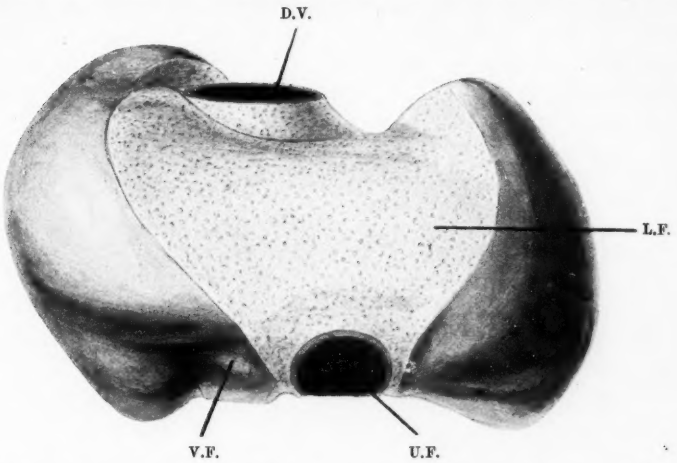

FIG. 4.—Specimen I., 7 mm. Model of liver seen from the ventral aspect. × 50.

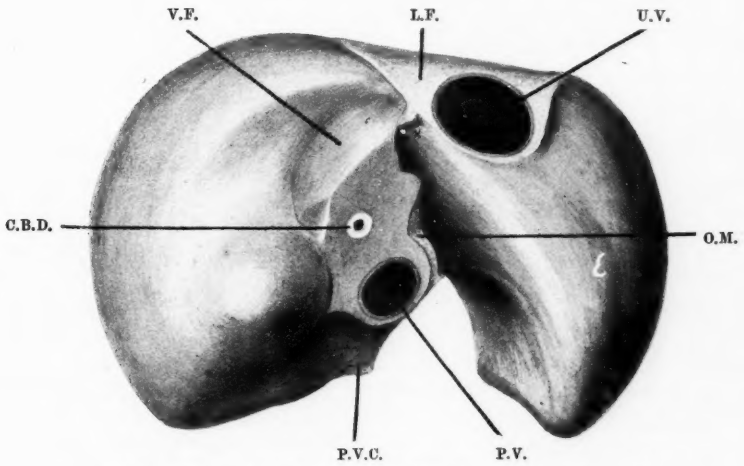

FIG. 5.—Same model as in fig. 4, seen from the caudal aspect. × 50.

which passes through the septum transversum to open into the right auricle. In fig. 5, which shows the model from the caudal aspect, some of

these points are brought out more clearly, and between the gall-bladder and the vena umbilicalis (marked with X) is seen the point where the quadrate lobe begins to differentiate. Dorsally (fig. 6) is the attachment of the omentum minus, with an area corresponding to the future lobus Spigelii on its right, and on the right of this again the plica venæ cavæ (*Nebengekröse*). Between these two mesenteries the pouch of peritoneum which foreshadows the bursa omentalis is formed as a diverticulum. The part between the liver and the alimentary tube is the recessus hepato-entericus, and the blind cranial end, which is prolonged so as to lie between

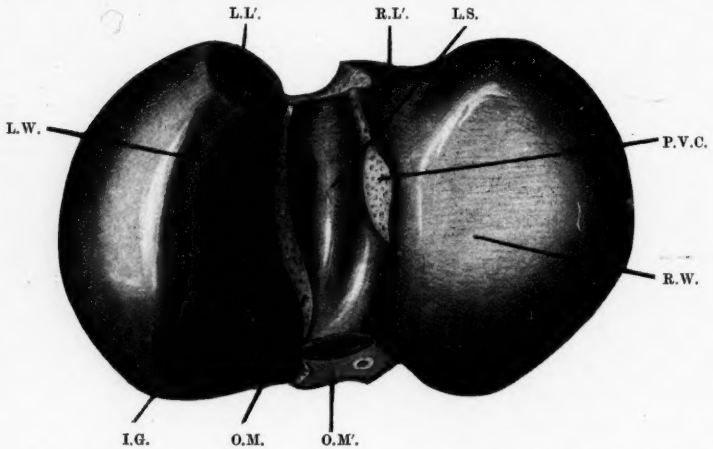

FIG. 6.—The same model as figs. 4 and 5, seen from the visceral surface. × 50.

the right lung bud and the alimentary tube, is the recessus pneumato-entericus. As the portion of the alimentary canal, with which this latter part of the recess is related, is the right side of the future œsophagus, it is sometimes termed the peri- or para-œsophageal cœlom. At the caudal end of the *Nebengekröse* is the foramen epiploicum. Here the general peritoneal cavity comes into communication with the recessus hepato-entericus by a long narrow passage across the back of the liver. The various areas of contact with neighbouring organs are sufficiently indicated in the figure.

SPECIMEN II.

The main features to be observed in fig. 7, which shows the model from the ventral aspect, are (1) the appearance of a small tubercle between the gall-bladder and the vena umbilicalis, the beginning of the lobus quad-

ratus; (2) the consequent pushing of the vena umbilicalis somewhat to the left; and (3) the prolongation of the caudal part of the right lobe into the abdominal cavity as an irregular process which comes into relation with the intestine. The irregular character of this extension is better seen in Specimen III. Mall (2) has drawn attention to a similar disposition in his models, and remarks "that in its growth the liver may atrophy in one portion and expand in another, the aberrant bile-ducts marking those portions of the liver which have been shifted. They are present in those

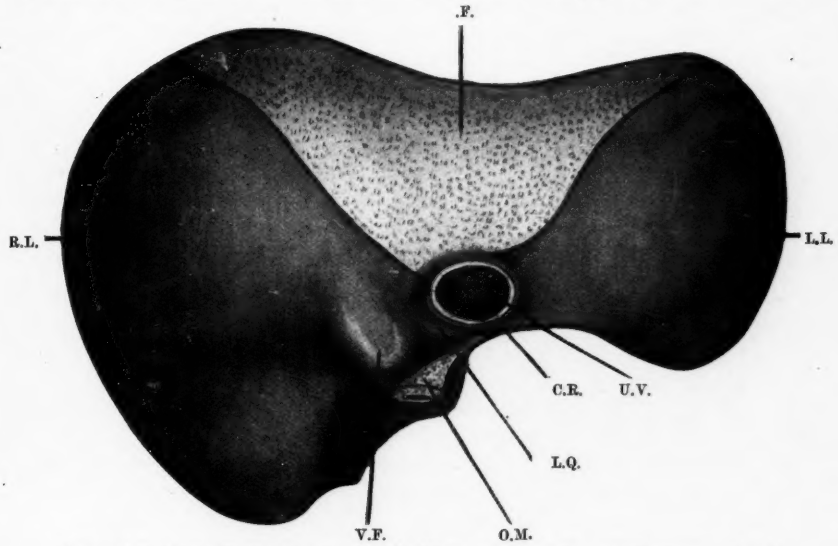

FIG. 7.—Specimen II., 11·25 mm. Model of liver, seen from the ventral aspect. ×37·5.

portions of the liver which had to make way for encroaching organs. Not only must large masses of the liver disappear entirely, but also smaller areas throughout the liver, especially along the trunk of the main vessels, as the liver is growing from its centre towards its periphery."

Although the incisura umbilicalis with the ligamentum falciforme and the fossa sagittalis sinistra are taken as the line of division between the right and left lobes of the liver in the adult, this is not borne out by the developmental history of the organ, or by injection experiments through the portal vein, as Rex's beautiful illustrations show. Nevertheless it is a highly convenient mode of description, and because of this its retention is justified. Cantlie (12) demonstrated in 1897 that a line drawn from the fundus of the gall-bladder to the exit of the hepatic veins divides the liver

into equal portions, the right and left lobes, and illustrated his contention by an interesting pathological specimen in which disease had destroyed the true right lobe, leaving the left lobe intact and greatly hypertrophied, and by other evidence. The embryological data supplied by my models support this view. It has been shown in Specimen I. that the line of attachment of the so-called ventral mesentery appears as a continuous attachment both on the ventral and dorsal aspects of the liver, and that the gall-bladder is placed in mesenchyme which is continuous with the

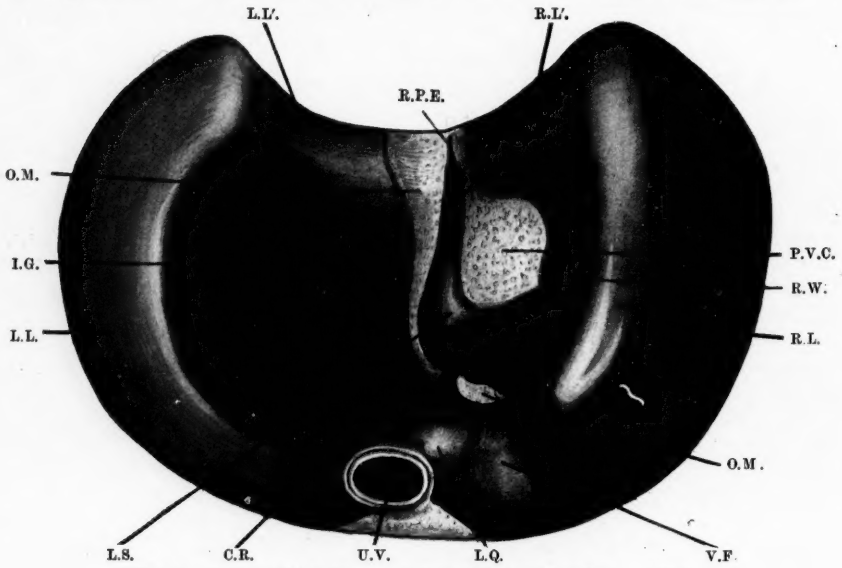

FIG. 8.—Same model as fig. 7, seen from the visceral surface. ×37·5.

omentum minus. The omentum minus is thin until we come to the portal fissure, where it forms a relatively thick mass. Together with the gall-bladder it can be regarded as the true median plane of the liver on the dorsal and caudal aspects. From the mesenchyme enveloping the gall-bladder a fold (fig. 5) runs cranially, as already stated, and joins the ligamentum falciforme, thus continuing the median plane on to the ventral surface. From this point the median plane can be indicated only in an arbitrary way, since, over a large area of the ventral surface, liver and septum transversum are fused together. However, if a line be drawn (fig. 4) from the fold just mentioned to the left border of the ductus venosus, it joins the cranial end of the omentum minus. The area which is marked X in fig. 5

is to the left of the fold, and is clearly a part of the left lobule. This is the preportal area, and indicates the place where the lobus quadratus will begin to develop.

On the dorsal surface (fig. 8) the attachment of the omentum minus is a conspicuous landmark. Further to the right is the plica venæ cava, and the foramen epiploicum in relation to its free caudal end. Between these two mesenteries is the bursa omentalis and the lobus Spigelii. The bursa omentalis at this stage is still called the recessus hepato-entericus, and its blind cranial end the recessus pneumato-entericus. The latter is becoming smaller in this specimen preparatory to being pinched off to form a closed sac, the bursa infracardiaca (see fig. 10), which lies, when present, in the adult just above the diaphragm, between the lung and the right side of the œsophagus. In a specimen of left diaphragmatic hernia in an adult recently examined here in the post-mortem room, this bursa was readily found on the right side, and measured $1\frac{1}{2}$ inches in length.[1] The quadrate lobule is well seen growing ventrally between the vena umbilicalis and the gall-bladder, and connected by a prominent ridge across the vein dorsally to another prominent ridge which forms the lateral boundary of the impressio gastrica on the left lobe. In fig. 2 the corresponding ridge has been noted. Its connexions and its relation to the ligamentum teres make it comparable with the ridge just described.

Specimen III.

Fig. 9 is a view of the liver from the ventral aspect. For a short distance, passing obliquely upwards and to the right from the vena umbilicalis, the two layers of the ligamentum falciforme have come together, or, in other words, the separation of the liver from the septum transversum is here practically completed. The fundus of the gall-bladder still reaches the ventral edge of the liver, and, owing to the development of the lobus quadratus on the left and the squarish mass of liver substance which is elevated between two deep impressions for the small intestine on the right, it now appears to be sunk in a cleft—the beginning of the deep cystic fissure,—which is such a striking feature of the liver of the fœtus towards the middle of the third month. In Specimens I. and II. it will have been noted that the gall-bladder with its investing mesenchyme, whilst being embedded in the under surface of the liver, presents one side, relatively extensive, which is superficial, and it is only as we approach the seventh week that a further sinking in becomes apparent. In reality it is the growth of liver substance on either side of it which in part, at any rate,

[1] The bursa is also well developed in the chacma baboon, and lies between the azygos lobe of the lung and the œsophagus.

produces the appearance of being placed in a cleft. In Mall's embryo 24 mm. (No. 10), *i.e.* about the end of the eighth week, the model of the liver shows the gall-bladder in a deep fossa, and the fundus some distance away from the ventral border.

In his well-known paper on the fissures of the human liver, Professor A. Thomson (1) draws special attention to the disposition of the gall-bladder in the fœtus at the end of the second month. At this period the gall-bladder lies in a well-marked fissure, and the fundus reaches a point about midway between the porta and the ventral border. Further, in 41

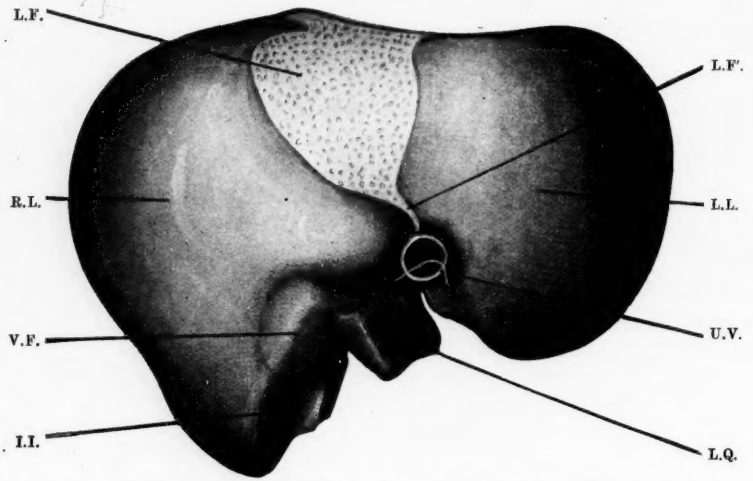

FIG. 9.—Specimen III., 16 mm. Model of liver, seen from the ventral aspect. × 25.

per cent. of all the cases examined, fœtal and adult, a fissure, continuous with the former, extended in front of the fundus as far as the ventral edge of the liver. This corresponds, in fact, with the fissure which Ruge (2) later on designated the fissura precystica. A. Thomson came to the conclusion, and rightly so, as my models show, that the gall-bladder developed in a fissure which extends forwards to the ventral border of the liver. He, however, came to regard the precystic fissure as preceding the appearance of the gall-bladder. From a study of my models it will be evident that up to the end of the sixth week the gall-bladder occupies the whole extent of the fissure. In older specimens it would appear that, owing to the liver and gall-bladder growing at different rates, the gall-bladder soon comes to occupy the position as shown in Mall's models (eighth week),

and in the earliest specimen figured by A. Thomson. If this view is correct, then the fissura precystica would represent the most ventral portion of the early cystic depression.

The lobus quadratus is in Specimen III. a well-developed lobule placed between the gall-bladder and the vena umbilicalis, and projecting ventrally for some distance. Uneven on the ventral surface, smooth and concave on the visceral surface, where it is moulded over the pyloric portion of the stomach, it is attached to the liver above and on its right; elsewhere it is free. A groove running from the gall-bladder on the right to the vena umbilicalis on the left limits it above (fig. 9). On its right edge is a small tubercle, whilst to the left it is flattened. De Burlet in his Object III. finds the tubercle on the left margin, not on the right, and names it the lobulus parumbilicalis. In each case it is probably an area of liver substance growing along a line of least resistance. In the specimen now described it would be, if a name were given to it, a lobulus paravesicalis.

A Thomson found that a small lobule, connected with the lobus quadratus on the visceral surface and adjacent to the fissura umbilicalis, was a common feature in the fœtal livers which he examined. He also met with it in anthropoids, and frequently in the adult human liver. Apparently it corresponds with the lobulus parumbilicalis which de Burlet found in his Object III. Ruge has suggested that some of these small outgrowths in adults are produced mechanically, and are in some way to be associated, causally, with the respiratory movements of the diaphragm. He has also described as a lobulus parumbilicalis a small outgrowth on the *left* lobe adjacent to the fissura umbilicalis A good example of this type is to be seen in the Museum of the Royal College of Surgeons, London.

There is no trace apparently of the right lateral fissure in Specimen III., but the possibility of it coinciding with the fossa of the gall-bladder must be remembered. If the fissure were present, as it is in de Burlet's Object II. (though it is absent in Object III.), then there seems no doubt that this process (fig. 10, L.Q.) would represent the lobus quadratus. When, however, the fissure is absent, the interpretation is more difficult. In such a case it may be regarded as representing a large part, and exceptionally the whole of the right central lobe. The abnormal adult specimen described above demonstrates, if the interpretation there given is right, that the right central lobe can and does develop as two moieties —right and left of the gall-bladder fossa. The right moiety is in fact a part of the right lobe, and has shared in the general growth and expansion of this lobe; on the other hand, the left moiety—lobus quadratus—seems to have some independence, and may be a small process as in the liver of

the adult pig, and in the abnormal specimen described above, or its growth may be precocious as in Specimen III., in the average normal human adult, and in many other mammals. In other words, as C. Bradley (5) has pointed out, the "lobus quadratus" appears to be of little importance in some animals, whilst in others it is evidently of much more moment. What may be the reason of this difference it is difficult to say. But as the lobe receives special vessels from the recessus umbilicalis, it seems reasonable to suppose that the size and number of the vessels will have

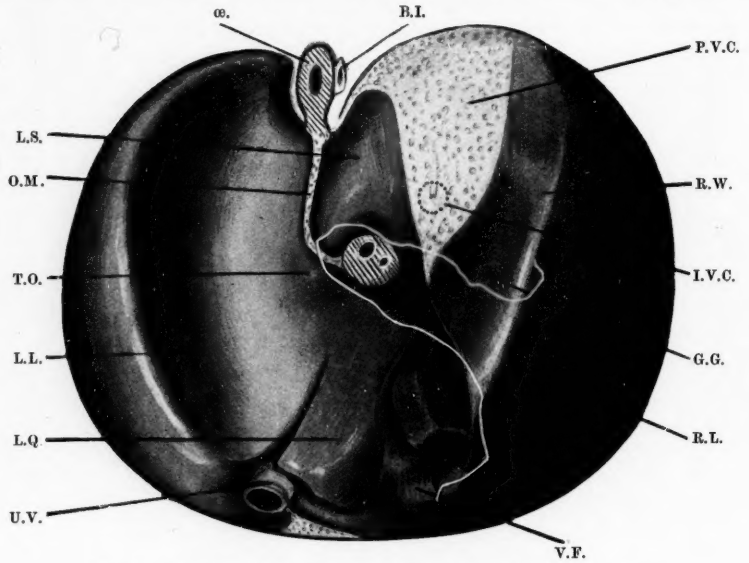

FIG. 10.—Same model as fig. 9, seen from the visceral surface. × 25.

some influence in determining the extent of its development. In this connexion I may quote the observation of Rex (4) in full:—"Ich möchte das Astwerk des R. umbilicalis in ein rechtseitiges und ein linksseitiges Scheiden. Das rechtseitige Astwerk versorgt jenem Abschnitt des mittleren Lappens welcher links von der Fossa cystica zu liegen kommt. Dieser Abschnitt entspricht dem 'Lobus' quadratus der ungelappten Organe." What Rex observed in the adult human organ, F. P. Mall has confirmed in the embryo. At the end of the fifth week vessels radiate from the recessus umbilicalis "into the middle and left lobules of the liver," *i.e.* just at the time when the quadratus lobule makes its appearance.

On the visceral surface (fig. 10) the extent of the preportal area can be

well seen, and a comparison made between it and the corresponding area in Specimen II. (fig. 8). On the right is the gall-bladder, and on the left the umbilical fissure. The latter, whilst extending to the ventral edge of the liver, stops short some distance in front of the porta, owing to the presence of a bridge of liver substance uniting the quadrate to the rest of the left lobe. In Specimens I. and II. the vena umbilicalis lies in a tunnel of liver substance, whilst in Specimen III. it is lying in a deep groove or fossa. The groove is incompletely covered over by the growth of two lips, one being the left lateral border of the quadrate, the other being a part of the left lobule. In Mall's three models, and in three of de Burlet's, *i.e.* in six cases, an open fissure occurred once only. Is the canal in which the vein runs in these cases an extension of the primary tunnel, or has it been formed secondarily by union of the lips over the fissure? Further, is the fissure present in my Specimen III. the result of a breaking down of the floor of a tunnel, or has it been formed by the growth of the lobus quadratus, as this grows from the region of the portal in a ventral direction? It is impossible to answer these questions finally from a study of my small series of models. All I can do is to state what I find in the specimens. The bridge over the fissura umbilicalis near to the porta is apparently primary, and on comparison with fig. 8 it will be seen that it is placed at the original point of junction of lobus quadratus with the left lobule, or, in other words, it indicates the area of the left lobule from which the lobus sprung. On microscopical examination there is no sign of an intervening raphé. The latter might be expected if the bridge had been formed by fusion of two lips. With regard to the fissura umbilicalis itself, it is not possible to speak so definitely. On examining the opposed lips of the fissure, there is a small area over which there is no peritoneum—where, indeed, it looks as if the tissue had recently broken down. This is near the bridge; elsewhere the peritoneum is a definite feature along the lips. One is thus precluded from stating that the fissure is primary in its whole course. On the other hand, it may be that the lips can unite for limited distances and then break down again. Obviously a large series of models about this period are necessary before any definite pronouncement can be made. However, should further investigation show that the open fissura umbilicalis at or about this stage—*i.e.* from five to six weeks—is a "primary" fissure, meaning by that term, a fissure formed as the lobus quadratus extends ventrally with its left margin free from the beginning, then there would seem good ground for regarding the lobus in man as something more than merely a quadrilateral area. Having these and other distinctive characters, the term "lobus," as applied to it in the consolidated organ such as occurs in man, would then appear to be justified.

Other features to be noted on the visceral surface of Specimen III. are the extensive area free from peritoneum, the plica venæ cavæ, with the orifice for the vena cava shown diagrammatically as it leaves the liver to enter into relation with veins on the posterior body wall. The lobus Spigelli is assuming more the form found in the adult, with a wide notch between the processus papillaris and the processus caudatus. The bursa omentalis extends dorsally behind the lobus Spigelii as far as the cranial limit of this lobe, where the blind end presents an uneven termination. Here are two minor recesses (seen also in Specimen II.), and from the dorsal one of the two the bursa infracardiaca has been pinched off to form the closed sac lying on the right side of the œsophagus, represented much strengthened in the figure, as the wall was too thin to model.

Therefore, although the lobus quadratus is not bounded by "true" fissures, yet, as these models show, it appears as a distinct process which develops into a definite hepatic area. This process grows as an extension of the left lobule, and at a different time and in a different way than the part of the right central lobe between the gall-bladder and the right lateral fissure. It may remain small or develop into a considerable area.

Finally, it may be noted that the pancreas obtained from the subject in which the abnormal liver was found also presented an interesting anomaly. The dorsal and ventral masses of the pancreas had failed to unite in the usual way; the duct of the dorsal pancreas was the main duct, and opened on a normal papilla minor, and the duct of the ventral pancreas opened, in common with the ductus choledochus, on the papilla major. No anastomosis between the two ducts could be traced.

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EXPLANATION OF FIGURES.

B.I. bursa infracardiaca.
C.B.D. ductus choledochus.
C.R. connecting ridge from lobus quadratus to left lobe.
D.V. ductus venosus Arantii.
G.B. gall-bladder.
G.G. area of contact, genital gland.
I.G. impressio gastrica.
I.I. impressio intestinalis.
I.V.C. inferior vena cava.
L.C. processus caudatus.
L.F. area of fusion between septum transversum and liver.
L.F'. ligamentum falciforme.
L.L. left lobe of liver.
L.L'. area of contact, left lung.
L.P. processus pyramidalis.
L.Q. lobus quadratus.
L.S. lobus Spigelii.
L.W. area of contact with Wolffian body.
O.M. omentum minus.
œ. œsophagus.
O.M'. thick mass of mesenchyme continuous with omentum minus.
P.V. vena porta.
P.V.C. plica venæ cavæ.
R.L.F. right lateral fissure.
R.L. right lobe of liver.
R.L'. area of contact, right lung.
R.P.E. recessus pneumato-entericus.
R.R.L. marginal rest of right lateral fissure.
R.W. area of contact, right Wolffian body.
T.O. tuber omentale.
U.A. uncovered area of right lobe.
U.V. vena umbilicalis sinistra.
V.F. mesenchyme surrounding gall-bladder.

THE CHARACTERS OF THE ENGLISH THIGH-BONE. By F. G. Parsons, *Professor of Anatomy in the University of London.*

This piece of work was undertaken in order to obtain, if possible, a standard of comparison for the various thigh-bones which we are so constantly digging up throughout the British Isles.

"How do these compare with a typical English femur?" we are often asked, and we have to say that nobody knows what a typical English femur is like any more than he knows what a typical English skull is like.

The bones in our dissecting-rooms are usually sawn into pieces, and even were they kept whole they would be of doubtful value, since they are almost always those of very aged people.

The femurs from which we teach, and those which our students buy, come from anywhere in Southern and Eastern Europe, so that, in order to get a type of an English femur, I have resorted to the great mass of bones beneath the church at Rothwell in Northants, which has been kindly placed at my disposal by the Vicar, Mr Morley.

Elsewhere (*Journ. R. Anthrop. Inst.*, vol. xl., 1910, p. 483) I have given my reasons for believing that these are the bones of mediæval English people who died in the thirteenth and fourteenth century, and, after being buried in the churchyard, were exhumed, according to the custom of the Middle Ages, and deposited in the disused chapel of the crypt.

These collections of bones in charnel-houses or crypts are plentiful enough in England, though they are usually walled up. I might have used the more accessible bones at Hythe; but a study of the skulls there convinces me that there is a large proportion of some particularly round-headed people among them whose origin is still a puzzle, and so I have felt doubtful whether their femurs could be regarded as fairly typical of those of Englishmen.

Of course I realise that a study of these Rothwell femurs will only entitle us to say what those of Midland Englishmen of the Middle Ages were like, but I hope that they will serve as a standard for comparison with more modern as well as with more ancient ones.

There is one thing which I am especially anxious to try to settle, and

that is, how many femurs it is necessary to examine in order to obtain a reasonable working average. At present, writers generalise on groups of 5, 10, 15, or 20, and we do not know what value to attach to their conclusions, but I hope that the detailed examination of 300 may throw some light on this.

Methods of Measuring.

The measurements which I have found necessary in order to reproduce a fairly accurate series of contours of a femur or type contours of a set of femurs are the following:—

1. *The oblique length.*—Measured in the ordinary way with a measuring board, the two condyles being placed in contact with the footplate of the board.

2. *The maximal length.*—The greatest length obtainable between the head of the femur and the internal condyle.

3. *The greatest diameter of the head.*—Measured with a sliding scale the two bars of which are kept parallel to the long axis of the neck of the femur. As a rule the greatest diameter of the head is nearly vertical.

4. *The least transverse diameter of the shaft.*—This is usually about the middle of the shaft, though sometimes, especially in platymeric femurs, it may be as low as the junction of the middle and lower thirds.

I think that this diameter is an important one to take, because it gives a clue to the robustness of the individual.

5. *The greatest antero-posterior diameter of the shaft.*—This is also, as a rule, best marked about the middle of the femur; it gives a record of the development of the linea aspera and should be contrasted with the index of bowing.

6. *The presence of a roughness or depression on the front of the neck of the femur.* This is quite close to the head and may be covered with articular cartilage. It is made by the anterior margin of the acetabulum close to the anterior inferior spine in full flexion of the hip, combined with internal rotation (see fig. 1).

7. *The antero-posterior width of the shaft just below the lesser trochanter.*—The measurement is taken from the inner side, and the bars of the sliding scale are not pushed far enough to take in the gluteal ridge, an abnormal development of which would vitiate the measurement.

8. *The transverse width of the shaft at the same place.*—This is always a larger measurement than the last, and by dividing it into the antero-posterior measurement multiplied by 100 the platymeric index of the femur is obtained. I should describe any femur giving an index under 75 as being distinctly platymeric to the eye.

9. *The width of the lower extremity.*—Taken with a sliding scale as in diagram No. 2. The importance of this measurement is that it is of value

Fig. 1.

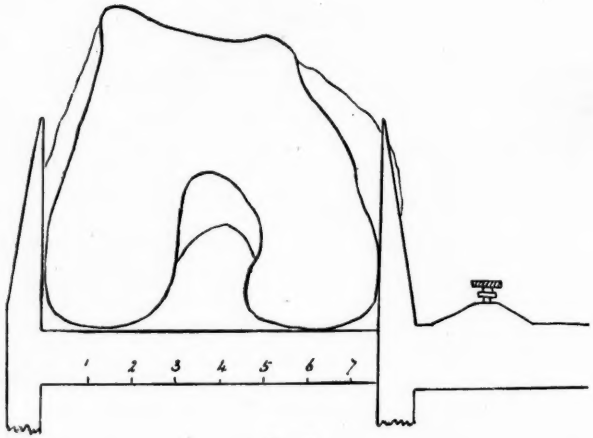


Fig. 2.

in sexing the bone, and, since it corresponds very closely with the width of the head of the tibia, it is likely to be valuable in sexing that bone too.

10. *The amount of antero-posterior bowing of the shaft.*—Taken by laying the femur close to the edge of a flat table in such a way that the posterior surfaces of both condyles are in contact with the table. The

sliding limb of the scale is then removed, and the scale placed vertically against the edge of the table, in such a way that the fixed limb touches the point of greatest convexity of the femur about the middle of the shaft. The distance of the most convex point from the surface of the table is then shown on the scale. By keeping the scale pressed against the side of the table edge, any deviation from the vertical is prevented.

11. *The index of bowing.*—As the mere amount of bowing would mean little unless it is taken in conjunction with the length of the femur, I have worked out an index of bowing by dividing the oblique length into the amount of bowing multiplied by 100; in this way the greater the index the greater is the bowing compared with the length of the femur.

12. *The angle of the neck.*—I am not quite clear how this angle has been taken by other writers. It will be evident to anyone looking at a femur that the angle which the upper border of the neck makes with the shaft is seldom the same as that which the lower border makes, because the neck widens from above downward as the junction with the shaft is approached. In taking the axis of the neck, I have drawn a line from the middle of the head to the middle of the base of the neck as seen from in front. The angle which this makes with the long axis of the middle of the shaft is the one I have taken (see fig. 1).

The length of the neck.—This is a variable and important measurement in reconstructing a type of a series of femurs. I measure it by resting a sliding scale along the front of the long axis of the neck, obtained as above. The head rests against the fixed bar of the scale, and the length is taken to the place where the long axis of the neck cuts the spiral line of the femur. Where this line is broad, the middle of it is taken.

The angle of torsion of the femur.—A special apparatus is made for measuring this, but I find that I can estimate the angle with considerable accuracy in the following way:—

A hole is drilled with a bradawl in the centre of the head of the femur —that is to say, in the upper and front part of the fovea capitis. The direction of the hole does not follow the long axis of the neck as seen from above, but is drilled in such a way that it would come out of the shaft just below the great trochanter, midway between its anterior and posterior margins (see fig. 3, line AB). This, I think, is important, as it is the torsion of the shaft which we wish to obtain. A long steel knitting-needle is placed in this hole.

Another hole is drilled in the internal condyle of the femur, starting on its inner side in front of the summit of the inner tuberosity, and running parallel to the surface of a table on which the femur is lying, so that the back of each condyle is touching the table (see fig. 3, line CD). Into this

another knitting-needle is placed. The points at which the two needles come out of the femur are then got into a line with the eye and the angle between the two rods measured with a transparent celluloid protractor while the bone is resting on a flat surface about the level of the eye.

Formerly I threw the shadows of the two rods on to a screen by a lamp placed in a line with them, then pencilled the shadows and measured the angle between them; but I find that I can get just as accurate results without this extra detail.

The method is not really as tedious as it sounds, but needs practice to be successful, and I should advise anyone adopting it to remeasure several femurs after an interval until he can be sure of not allowing more than two or three degrees of discrepancy.

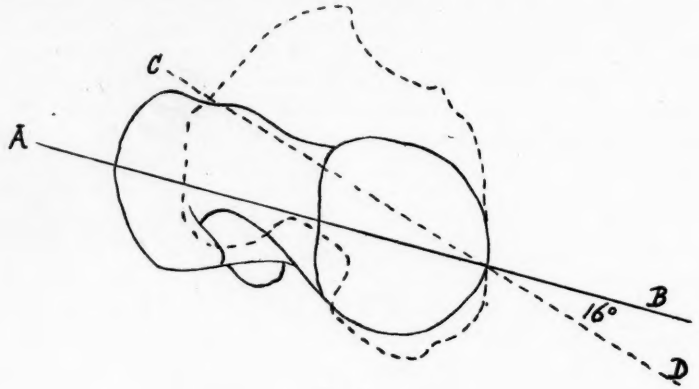


Fig. 3.

The obliquity of the shaft.—I measure with a goniometer having a long pointer, which can be placed in front of the long axis of the femur, the two condyles of which are resting on a flat surface. The angle recorded is that between the obliquity of the shaft and the vertical.

It will now be advantageous to consider the main points which can be learnt from the accompanying tables of measurements:—

1. *The oblique length.*—On the left side this averages 456 mm. in the male bones, and 453 mm. on the right side, while in the female bones the left average 418 mm. and the right 415 mm. It will thus be seen that in both sexes the left side averages 3 mm. more than the right. It must, of course, be remembered that the right bones measured were not necessarily the fellows of the left: indeed, it is not very likely that many were, because 22,000 heads of femurs were counted in restacking the bones, showing that

the remains of at least 11,000 people are in the vault. In relation to this I have lately measured the two femurs of 16 bodies in the dissecting-rooms of St Thomas's and Guy's Hospitals, and find that the average of the left femurs is also 3 mm. more than that of the right.

The maximal length is more important, because from it Pearson has prepared his valuable charts for the reconstruction of the stature. In the males the left femurs average 460 mm. and the right 456, while in the females the left average 422 and the right 416. In the male bones, therefore, there is a difference between the oblique and the maximal lengths of 3 to 4 mm., while in the female bones there is a difference of 1 mm. on the right side and 4 on the left. This is rather a serious discrepancy between the two sides, which makes me a little uneasy, and I can only say that the measurements were taken with great care, and I can detect no flaw in my calculations. Possibly if the numbers of the female bones had been greater the discrepancy might have disappeared. Pearson (*Phil. Trans.*, vol. excii., series A, p. 197) says that 3·2 mm. should be added to the oblique length in the male in order to get the maximal length, and 3·3 mm. in the female. This, from my figures, seems a fair enough average, but it must be borne in mind that the individual variation is very great, some bones having as much as 11 mm. difference between the two measurements, and others none at all.

It seems reasonable to suppose that when there is an unusual difference between the maximal and oblique measurements, it is due to a greater obliquity than usual in the femur. In order to test this, I took the average obliquity of 21 male femurs in which there was a difference of more than 5 mm. between the maximal and oblique lengths. I found this average to be 11°, which is 2° above the average obliquity of all the male bones.

Among the left female femurs the average obliquity is 11°, but the average of those with more than 5 mm. between the two lengths is 12·7°.

The right female femurs give an average obliquity of 10°, but the average of those with more than 5 mm. between the two lengths is 11·5°.

It has been said that from the maximal length Pearson deduces the average stature of the series. I am not quite clear why he chooses the maximal in preference to the oblique length, since the latter is the one which really forms a fraction of the body height; but as I have not the mathematical knowledge to adapt his work to the oblique length, I am only too glad to avail myself of it as it stands.

The average maximal length of the right male Rothwell bones is 456 mm., and of the left 460 mm. This, according to his chart, would give a height of 167 cm., or 5 feet 5¾ inches, for the men.

Right Male Femurs from Rothwell.

Number of Femur measured.	Oblique Length.	Maximal Length.	Diameter of Head.	Least Transverse Diameter of Shaft.	Greatest Ant.-Post. Diameter of Shaft.	Facet in Front of Neck.	Width of Lower Articulation.	Platymeria. Ant.-Post.	Platymeria. Transverse.	Platymeria. Index.	Amount of Bowing.	Index of Bowing.	Angle of Torsion.	Length of Neck.	Angle of Neck.	Obliquity of Shaft.	Remarks.
1	...	453?	51	31	31	...	...	23	39	59	65	144	° ...	62	124°	° ...	
2	463	468	50	31	35	...	78	30	38	79	60	130	10	65	118	9	
3	447	452	48	27	33	No	76	29	31	93	62	138	10	57	132	8	Third trochanter present.
4	454	457	49	30	35	,,	75	28	34	82	62	138	7	59	128	8	
5	453	455	47	30	33	Yes	75	29	34	85	55	122	8	65	130	7	
6	406	410	46	29	28	,,	74	26	33	79	60	146	13	59	120	9	
7	475	479	51	32	31	,,	79	28	39	72	60	128	− 5	71	116	10	
8	466	469	49	31	33	,,	78	29	35	83	61	130	− 4	69	130	7	
9	453	461	52	29	29	...	83	28	35	80	59	131	18	68	123	12	
10	483	485	54	31	33	Yes	83	31	38	82	65	135	15	69	127	7	
11	455	463	49	27	35	,,	68	28	31	90	69	153	23	60	132	10	
12	438	444	50	29	31	,,	78	28	36	78	64	145	10	67	130	10	
13	472	473	51	31	33	,,	81	29	37	78	64	136	20	71	124	5	
14	492	495	51	31	31	,,	83	28	31	90	59	120	17	70	126	7	
15	455	457	51	33	34	,,	76	29	31	93	71	158	24	63	125	8	
16	..	455?	49	30	31	,,	...	26	31	84	61	136	...	72	130	...	
17	455	457	50	28	34	,,	76?	32	35	91	67	149	25	63	127	8	
18	461	465	47	28	31	,,	75	28	32	87	58	126	3	64	125	11	
19	452	455	49	29	30	No	77	28	32	87	64	142	9	58	135	10	
20	464	467	50	30	35	Yes	76	35	39	90	71	154	20	67	121	8	
21	450	452	47	31	32	...	78	33	34	97	65	144	15	59	121	9	
22	460	463	46	30	31	Yes	77	26	37	70	63	137	18	55	130	8	
23	465	467	48	29	29	,,	75?	28	35	80	55	119	...	64	125	10	
24	463	469	50	31	30	...	77	29	35	83	55	119	8	65	122	11	
25	457	459	54	31	32	Yes	87	31	37	84	58	126	28	69	123	9	
26	...	465	46	32	30	,,	...	28	33	85	60	130	25	62	130	13	The sex of this is doubtful.
27	473	474	54	32	33	,,	81	30	38	79	65	138	6	86	121	7	
28	482	485	49	30	31	...	79	29	38	76	65	135	17	67	131	8	
29	439	442	47	29	31	Yes	81	30	33	91	69	157	25	62	125	9	
30	426	431	46	30	31	,,	69	32	33	97	60	140	20	59	122	13	
31	404	409	46	30	28	...	76	28	35	80	63	157	17	58	117	11	
32	453	455	50	28	26	...	75?	24	38	63	58	129	19	57	122	11	
33	474	478	49	32	33	Yes	75	25	34	73	55	117	17	63	133	10	
34	438	440	49	32	36	No	75	28	43	65	63	143	20	65	113	8	
35	457	460	48	29	33	Yes	81	28	35	80	67	146	− 1	67	120	8	
36	487	490	51	30	33	...	78	28	34	82	68	139	...	65	131	8	

37	480	483	52	...	...	Yes	78	32	38	84	...	...	30	67	127	10	Signs of an early greenstick fracture [of shaft.
38	440	445	45	28	30	...	...	31	36	86	...	...	...	64	124	12	
39	459	465	51	30	30	Yes	77	29	34	85	60	130	10	64	130	9	
40	470	473	...	33	38	...	79	32	40	80	56	119	−2	74	140	8	
41	438?	..	...	30	32	...	76	28	37	76	53	120	...	...	128	7	
42	442	445	...	27	29	...	74	30	30	100	55	125	15	65	138	7	
43	445?	...	...	30	30	...	78	30	34	88	60	136	...	...	...	9	
44	460	464	50	29	31	Yes	77	28	37	76	60	130	12	70	126	8	Slight osteo-arthritis of lower end.
45	457	460	47	27	27	,,	72	25	34	73	54	118	8	66	120	10	
46	448	448	52	30	33	...	76	33	34	97	60	133	12	70	122	4	
47	438	444	47	26	32	No	70	26	32	81	71	161	12	67	136	10	
48	455	458	47	27	31	Yes	75	28	33	85	59	131	0	66	130	9	
49	...	440?	51	29	30	,,	..	27	35	77	56?	127	12	66	130	...	
50	471	475	49	31	31	No	...	29	40	72	59	126	20	67	117	11	
51	430	432	52	29	30	...	74	28	34	82	53	123	22	73	128	8	
52	451	454	48	28	34	No	76	29	33	88	64	142	−2	61	131	10	
53	470	475	54	30	32	Yes	87	30	39	77	63	133	11	78	125	11	
54	417	418	48	25	28	No	77	28	33	85	59	140	11	60	127	6	
55	479	490	48	31	30	...	77	27	34	79	58	121	20	64	124	13	
56	482	484	54	32	33	Yes	83	29	37	78	65	135	12	75	131	10	
57	474	...	52	30	31	...	...	31	37	84	...	...	...	63	125	...	
58	...	432	51	24	34	No	...	28	31	90	65	151	20	66	130	...	
59	475	479	49	26	31	...	...	28	31	90	...	...	...	71	135	...	
60	444	452	47	30	29	Yes	73?	25	36	69	60?	136	...	67	123	...	
61	444	449	50	28	28	,,	75	26	36	72	53	120	18	65	123	12	Osteo-arthritis of head.
62	465	471	45	28	30	,,	77	28	33	85	63	137	12	71	130	10	Osteo-arthritis of lower end.
63	432	439	49	25	31	,,	71	29	31	94	56	130	10	66	135	14	
64	474	474	54	32	34	No	80	31	38	82	68	145	13	72	122	6	
65	463?	...	52	30	30	Yes	...	30	33	91	...	...	...	74	126	...	
66	448	452	46	29	36	,,	...	29	30	97	68	151	12	67	135	8	Third trochanter.
67	421	423	47	29	28	...	75	26	40	65	61	145	12	55	122	10	Groove outside gluteal ridge.
68	417	422	47	30	29	Yes	73	28	34	82	60	143	20	60	120	12	Groove outside gluteal ridge.
69	440	442	51	31	34	,,	76	31	35	89	75	170	22	61	118	11	
70	441	443	49	26	32	No	82	28	30	93	64	145	7	61	131	6	
71	442	449	47	27	30	Yes	69	27	30	90	59	134	10	67	138	11	
72	449	452	50	29	33	,,	72	29	34	85	65	144	−2	68	128	9	
73	419	422	49	25	30	...	74	27	30	90	62	148	23	62	130	9	
74	450	453	49	30	31	No	...	28	36	67	56	125	...	67	125	...	
75	473	475	48	30	31	Yes	75	27	38	71	60	128	15	65	120	8	
76	424	426	45	27	30	No	77	27	34	79	62	148	7	64	128	8	
77	470	473	48	30	30	Yes	78	29	34	85	65	138	14	65	131	10	
78	444	448	49	27	29	,,	75	28	31	90	55	125	1	66	131	10	
79	427	433	46	27	30	,,	70	24	32	75	60	140	10	62	125	9	Groove outside gluteal ridge.
80	428	440	45	27	31	,,	74	25	32	78	59	137	−13	60	120	17	
	mm.	mm.	mm.	mm.	mm.	Present	mm.	mm.	mm.		mm.			mm.			
Average.	453	456	49	29	31	in	75	27	35	77	61	135	13	65	127	9	
	(75)	(76)	(76)	(79)	(79)	79%	(68)	(80)	(80)	(80)	(75)	(75)	(69)	(78)	(79)	(71)	

Left Male Femurs from Rothwell.

Number of Femur measured.	Oblique Length.	Maximal Length.	Diameter of Head.	Least Transverse Diameter of Shaft.	Greatest Ant.-Post. Diameter of Shaft.	Facet on Front of Neck.	Width of Lower Articulation.	Platymeria. Ant.-Post.	Platymeria. Transverse.	Platymeria. Index.	Amount of Bowing.	Index of Bowing.	Angle of Torsion.	Length of Neck.	Angle of Neck.	Obliquity of Shaft.	Remarks.
1	479	485	55	30	38	Yes	81	33	39	85	64	133	7°	72	134°	9°	
2	468	473	49	32	36	No	79	31	40	77	63	133	10	69	124	9	
3	469	471	51	32	32	Yes	77?	35	37	95	61	130	18	71	135	...	
4	492	494	55	32	32	,,	...	31	38	82	...	...	...	73	133	...	
5	470	471	49	30	40	,,	79	30	36	83	69	147	7	67	126	5	
6	460	463	47	30	33	,,	...	30	36	83	60	130	0	65	130	14	
7	452	452	53	29	35	,,	77	30	38	79	60	133	8	70?	122	7	
8	467	467	47	31	37	...	76	28	35	80	63	133	12	64	128	10	
9	480	483	54	33	32	Yes	82	31	39	79	64	133	20	70	127	8	
10	480	484	52	29	32	,,	79	28	36	78	58	121	20	74	133	9	
11	454	458	47	28	39	No	78	30	33	91	72	160	20	60	126	12	Least breadth above middle of shaft.
12	469	472	50	30	34	Yes	77	31	36	86	63	133	3	68	132	10	
13	474	476	...	28	36	...	75?	31	38	82	61	130	22	72	126	7	
14	480	...	49	35	35	Yes	...	30	39	77	...	...	5	72	112	...	
15	451	453	54	33	31	No	84	29	42	69	62	138	35	70	124	10	
16	482	485	55	32	29	Yes	82	33	39	85	58	121	16	65	129	8	
17	475	479	49	32	36	No	82	31	37	84	73	155	10	62	124	9	
18	474	480	49?	32	33	...	79	29	41	71	68	145	15	71	128	13	
19	481	486	53	33	34	Yes	80	34	41	83	52	109	0	67	118	10	
20	...	...	51	34	35	No	...	33	45	73	...	...	...	70	118	...	
21	463	468	52	25	37	?	82	30	32	94	78	170	7	69	125	7	Least breadth above middle. Rickets.
22	460	461	48	29	34	Yes	75	31	36	86	55	119	8	73	131	9	
23	475	482	49	32	32	,,	72?	30	35	86	55	117	3	68	120	10	
24	494	496	49	32	32	No	80	27	36	75	65	133	25	70	138	9	
25	464	467	53	28	33	Yes	78	32	35	91	65	141	25	65	126	9	
26	454	459	49	28	33	No	75	32	32	100	...	...	19	60	133	9	
27	451	459	50	30	35	Yes	75	33	34	97	67	149	12	60	121	14	
28	467	468	53	31	33	,,	78	28	38	74	62	132	17	70	128	8	Groove outside gluteal ridge.
29	441	444	51	30	30	,,	79	28	37	76	55	125	7	70	125	10	
30	430	432	47	35	30	,,	65?	30	42	71	...	...	0	62	114	13	Groove outside gluteal ridge.
31	450	450	49	31	33	...	75	29	38	76	68	151	11	67	129	7	
32	459	464	48	25	27	No	79	29	33	88	60	130	17	60	126	10	
33	477	479	50	32	31	...	...	29	35	83	60	125	13	71	134	10	

34	472	474	48	29	32	No	75	30	35	86	61	130	26	63	128	7	Slight groove outside gluteal ridge.
35	431	435	49	29	32	,,	76	27	35	77	65	151	5	60	122	11	[Slight third trochanter.
36	469	472	49	33?	34	?	82	32	37	86	60	128	10	60	123	9	
37	431	433	47	30	33	Yes	71?	26	35	74	67	156	2	70	127	9	
38	436	438	46	30	30	,,	75	27	36	75	59	134	18	60	125	9	
39	483	485	53	31	33	,,	79	30	39	77	63	131	12	73	128	11	
40	457	462	46?	28	34	...	78	30	35	86	57	124	30	64	125	10	
41	471	478	50	30	29	No	72	26	34	76	58	123	0	65	130	13	
42	433	434	45	31	32	Yes	76	29	36	81	60	140	8	61	117	7	
43	481	485	49	28	33	Yes	75	29	36	81	65	135	40	65	128	8	Slight groove outside gluteal ridge.
44	443	448	48	32	31	No	82	30	38	79	62	141	15	62	118	12	
45	414	416	47	29	30	...	73	28	34	82	58	141	17	67	123	10	
46	450	457	51	32	33	Yes	...	29	38	76	63	140	−2	70	130	11	
47	459	462	50	27	33	,,	71	27	33	82	63	137	7	63	137	11	Groove outside gluteal ridge.
48	452	454	50	29	30	,,	75	30	35	86	60	133	17	75	134	10	
49	461	465	49	30	31	...	...	28	35	80	58	126	17	59	134	11	Slight groove outside gluteal ridge.
50	445	449	46	29	31	Yes	75	28	33	85	60	136	11	61	131	11	
51	442	444	52	29	31	No	81	29	39	74	59	134	25	72	120	8	
52	468	472	47	27	28	Yes	72	28	30	93	55	117	19	67	125	11	
53	460?	...	...	30	28	...	77	28	33	85	60	130	...	...	132	7	Third trochanter.
54	480	482	51	30	36	Yes	80	30	35	86	63	131	15	66	120	9	
55	432?	...	47	27	32	,,	...	28	36	78	57	133	13	60	123	...	
56	480	482	50	27	33	,,	82	28	35	80	57	119	5	72	128	8	
57	430	434	...	28	30	,,	73	28	36	78	62	144	27	63	127	10	
58	448	452	50	27	29	,,	75	27	35	77	65	144	16	68	128	9	
59	467	472	49	30	33	,,	79	33	34	97	58	123	12	65	130	8	
60	442	446	47	28	38	,,	77	29	35	83	71	161	9	61	115	9	
61	446	447	47	31	31	,,	75?	38	38	100	54	120	23	70	122	8	
62	447	457	47	29	28	,,	71	29	35	83	47	104	20	60	131	12	
63	538	543	51	30	37	,,	82	28	35	80	68	126	17	83	135	9	
64	458	459	49	31	33	No	79	29	36	81	65	141	6	63	120	4	
65	455	461	52	30	30	Yes	76?	29	36	81	55	122	16	66	123	13	
66	417	420	47	30	32	,,	76	29	37	78	61	145	10	60	117	10	
67	441?	...	45	28	33	,,	71?	33	34	97	67?	152	28	58	127	...	
68	442	442	47	30	31	...	82	30	36	83	55	125	20	71	120?	8	
69	421	424	47	28	30	...	72	27	36	75	55	131	8	55	130	8	
70	437	439	...	28	31	...	74	27	32	84	62	141	...	67	125	8	
71	433	436	49	27	30	...	76	27	33	82	56	133	22	65	127	10	
72	455	459	45	28	29	...	69	28	35	80	52	116	25	62	127	10	
73	455	458	47	30	33	Yes	73	28	36	78	61	135	20	62	119	8	
74	461	465	53	27	27	No	76	27	31	87	55	119	15	60	124	10	
75	447	449	47	30	35	Yes	76	28	35	80	65	144	0	64	127	10	
76	450?	...	...	31	31	...	82	32	38	84	60	133	17	...	115	10	
77	483	486	50	32	38	...	77	30	40	75	70	146	13	65	120	10	
78	435	439	47	29	29	Yes	72	29	37	78	59	137	17	62	130	10	

LEFT MALE FEMURS FROM ROTHWELL—*continued.*

Number of Femur measured.	Oblique Length.	Maximal Length.	Diameter of Head.	Least Transverse Diameter of Shaft.	Greatest Ant.-Post. Diameter of Shaft.	Facet on Front of Neck.	Width of Lower Articulation.	Platymeria. Ant.-Post.	Platymeria. Transverse.	Platymeria. Index.	Amount of Bowing.	Index of Bowing.	Angle of Torsion.	Length of Neck.	Angle of Neck.	Obliquity of Shaft.	Remarks.
79	467	469	51	31	31	Yes	79	27	38	71	61	130	°5	64	128°	°8	Slight groove on outer side of gluteal [ridge.
80	448	451	49	29	35	,,	78	30	36	83	60	133	12	66	125	10	
81	457	459	52	33	33	,,	78	29	39	74	57	124	5	68	120	10	
82	444	445	47	30	31	,,	78	29	35	83	61	139	7	61	126	10	
83	...	466	49	28	33	,,	...	27	36	75	62	135	9	65	121	...	
84	439	442	51	32	31	,,	78	29	38	76	58	132	18	70	126	11	Slight groove on outer side of gluteal [ridge.
85	443	450	48	29	31	,,	77	31	39	79	54	123	0	65	121	11	
86	464	465	49	32	31	,,	78	29	38	76	60	130	21	73	124	7	Slight groove on outer side of gluteal [ridge.
87	445	450	50	30	31	,,	77	31	40	77	59	134	5	65	...	10	
88	472	475	50	32	34	,,	82	32	40	80	62	132	10	65	120	9	
89	475	479	48	31	35	,,	82	31	36	86	62	132	−6	70	127	8	Very marked muscular ridges.
90	453	456	45	30	32	,,	74	28	36	78	60	133	13	65	127	11	
91	438	443	48	29	30	,,	79	31	35	89	56	127	13	67	137	11	
92	455	457	45	30	34	,,	77	31	34	91	53	118	5	66	127	9	
93	440	442	48	28	32	,,	76	28	38	74	57	129	15	66	125	8	
94	450	453	52	32	28	...	77	28	35	80	53	118	11	69	126	12	
95	454	458	49	32	34	Yes	72	31	35	89	53	118	15	70	127	11	
96	428	432	49	29	31	...	81	31	34	91	55	128	3	61	126	8	
97	445	449	47	29	32	No	73	28	35	80	55	125	22	60	117	10	Groove on outer side of gluteal ridge.
98	477	480	47	30	31	Yes	77	30	34	88	62	129	28	63	127	11	[Third trochanter.
99	421	424	48	32	31	No	80	28	35	80	71	171	28	60	127	8	
100	443?	446?	...	28	30	Yes	...	28	34	82	54?	123	...	...	120	9	
101	440	446	49	28	32	,,	76	31	32	97	64	145	21	63	130	11	
102	...	438	47	31	32	...	..	26	38	68	51	119	...	60	126	11	Groove on outer side of gluteal ridge.
103	458	463	47	29	30	Yes	...	29	37	78	52	113	18	65	126	9	
104	440?	...	...	31	33	...	...	28	37	76	...	...	...	70?	122	...	
105	463	468	49	32	33	Yes	77	27	39	69	59	128	6	67	128	10	Groove on outer side of gluteal ridge.
	mm.	mm.	mm.	mm.	mm.	%	mm.	mm.	mm.		mm.		°	mm.	°	°	
Average.	456 (102)	460 (98)	49 (98)	30 (105)	32 (105)	79	77 (92)	29 (105)	36 (105)	81 (105)	62 (95)	135 (95)	13 (98)	66 (102)	126 (104)	9 (97)	

Right Female Femurs from Rothwell.

Number of Femur measured.	Oblique Length.	Maximal Length.	Diameter of Head.	Least Transverse Diameter of Shaft.	Greatest Ant.-Post. Diameter of Shaft.	Facet in Front of Neck.	Width of Lower Articulation.	Platymeria. Ant.-Post.	Platymeria. Transverse.	Platymeria. Index.	Amount of Bowing.	Index of Bowing.	Angle of Torsion.	Length of Neck.	Angle of Neck.	Obliquity of Shaft.	Remarks.
1	397	400	42	30	28	No	67	26	33	79	57	143	10°	50	119°	10°	
2	462	464	41	24	28	,,	63	22	30	73	58	126	30	52	127	5	Groove external to gluteal ridge.
3	471?	477	44	28	32	,,	66?	27	33	82	58	123	15	57	130	...	Groove external to gluteal ridge [(slight).
4	400?	402	43	30	30	Yes	...	24	35	69	65	163	30	56	120	9	
5	412	413	45	27	28	,,	70	27	33	82	61	149	12	58	127	8	
6	423	428	42	26	26	,,	66	27	30	90	60	143	15	59	128	9	
7	406	408	43	24	26	...	...	27	32	84	57	139	11	54	129	8	
8	452	458	46	31	33	...	74	29	36	81	60	133	5	63	130	10	
9	415	422	42	27	31	No	67	27	33	82	62	151	17	53	125	11	Groove external to gluteal ridge.
10	408	412	43	27	27	..	...	25	34	73	56	137	...	56	116	10	
11	399	404	43	26	27	Yes	66?	24	35	69	57	143	30	57	119	11	
12	394	398	41	28	24	...	65?	25	32	78	55	141	22	57	127	10	
13	413	419	42	26	28	...	70	27	34	79	52	125	20	60	128	11	
14	414	420	45	26	28	Yes	72	28	39	72	55	134	31	59	121	11	
15	389	393	42	26	26	No	68	26	33	79	60	154	18	52	122	9	
16	423	425	44	26	29	...	64	27	32	84	45	107	13	56	127	8	
17	423	425	42	27	28	Yes	68	25	34	73	53	126	25	55	133	7	Exostosis in origin of short head of [biceps femoris.
18	450	454	45	28	31	No	71	27	35	77	67	149	17	59	120	12	
19	393?	...	39	26	26	Yes	...	25	31	81	49	126	25	52	122	...	
20	445	453	43	25	28	No	67	25	27	98	58	132	28	58	132	12	
21	432	436	45	27	30	...	70	26	35	74	56	130	10	62	126	11	Groove external to gluteal ridge.
22	399	403	48	28	27	...	67	23	34	68	54	135	8	55	126	10	Obviously ♀ in spite of size of head.
23	...	425?	42	28	29	No	...	26	30	87	...	...	...	54	127	...	
24	425	432	45	29	30	Yes	69	24	31	77	55	131	14	59	131	11	
25	404	406	44	28	29	No	69	24	32	75	52	130	17	52	124	7	Groove external to gluteal ridge.
26	450	453	45	24	30	Yes	...	22	30	73	59	131	5	62	134	9	
27	448	451	44	27	29	...	67	29	32	91	59	131	5	62	114	10	
28	396	399	41?	27	30	...	66	25	33	76	65	162	21	...	130?	10	
29	425	429	44	30	29	Yes	67	28	36	78	65	155	18	58	122	10	
30	399	407	42	29	24	,,	64	24	31	78	50	125	32	50	130	12	
31	379	382	40	27	24	,,	64	23	32	72	52	137	18	58	124	8	
32	420	425	43	25	28	...	68	24	29	83	57	136	12	57	126	9	
33	407	416	44	29	31	...	69	28	33	85	63	154	18	56	129	10	
34	434	437	45	28	27	Yes	71	23	34	68	61	142	2	58	127	9	
35	356	358	36	22	25	No	63	23	27	85	52	144	22	53	122	9	
36	425	436	43	25	29	Yes	71	27	28	96	57	136	24	62	120	14	
37	447	455	43	28	28	,,	72	26	32	81	57	127	2	61	129	11	

Right Female Femurs from Rothwell—*continued.*

Number of Femur measured.	Oblique Length.	Maximal Length.	Diameter of Head.	Least Transverse Diameter of Shaft.	Greatest Ant.-Post. Diameter of Shaft.	Facet in Front of Neck.	Width of Lower Articulation.	Platymeria: Ant.-Post.	Platymeria: Transverse.	Platymeria: Index.	Amount of Bowing.	Index of Bowing.	Angle of Torsion.	Length of Neck.	Angle of Neck.	Obliquity of Shaft.	Remarks.
38	388	394	41	25	27	No	65	26	31	84	48	123	11°	54	130°	8°	(41)
39	400	404	40	25	26	...	...	24	27	89	58	145	...	53	130	10	
40	406	415	40?	28	31	No	69	27	31	87	60	146	11	54	122	13	
41	420	...	43	25	26	...	...	26	34	76	51	121	34	60	126	...	
42	411	413	43	26	26	No	65	24	31	78	55	134	10	53	126	8	
43	442	448	45	25	27	...	67	24	30	80	65	148	22	55	...	10	Groove external to gluteal ridge.
44	398	405	40	25	25	...	68	24	32	75	55	137	30	55	132	12	
45	402	405	45	28	31	...	71	26	33	79	59	148	20	54	125	9	
46		383?	43	26	26	No	...	23	30	77	45	118?	...	55	126	...	Deep pit in long axis of front of neck.
47	397	401	41	23	23	,,	64	23	30	77	48	120	25	51	128	10	
48	413	420	45	25	26	Yes	...	28	31	90	49	120	29	58	120	13	
49	412	421	40	29	25	,,	70	27	32	84	50	122	10	63	126	13	
50	403	408	42	24	27	...	67	25	28	89	53	133	25	50	133	8	
51	388	392	41	25	24	...	...	23	31	74	48	123	8	62	123	10	
52	422	425	45	30	26	Yes	72	27	31	87	55	131	17	59	124	10	
53	...	373?	41	25	25	,,	...	24	28	86	54	146	...	54	126	...	
54	420	427	45	26	30	...	68	26	34	76	60	143	27	52	132	12	
55	...	396?	41	27	26	...	...	24	33	73	57	146	...	55	125	...	
56	414	422	41	21	23	...	...	23	29	79	...	...	...	60	126	13	
57	406	412	43	25	26	...	68	25	30	83	50	122	12	49	129	11	Marked osteo-arthritis of head.
Average.	mm. 415 (52)	mm. 416 (53)	mm. 43 (55)	mm. 26 (55)	mm. 28 (55)	Present in 58%	mm. 68 (42)	mm. 25 (55)	mm. 32 (55)	78 (55)	mm. 56 (54)	137 (54)	18 (49)	mm. 56 (54)	126 (54)	10 (49)	

Left Female Femurs from Rothwell.

1	414	418	43	27	28	...	69	27	32	84	63	154	−3°	58	123	14°	
2	457	461	39	26	27	Yes	63	23	32	72	53	115	30	57	126	6	Groove outside gluteal ridge.
3	429	432	44	26	30	No	69	24	33	73	58	135	30	57	126	9	
4	412	413	45	26	27	...	69	24	35	68	60	146	23	58	122	6	Groove outside gluteal ridge.
5	422	425	43	25	31	Yes	75	25	33	76	57	136	18	60	128	9	
6	412	416	...	26	26	...	67	25	32	78	53	129	20	...	129	10	Osteo-arthritis of head.
7	420?	...	43	27	30	No	...	27	33	82	55	131	10	54	127	...	
8	438	444	...	28	28	...	68	25	32	78	57	129	12	55	118	13	

9	403	409	40	26	24	...	67	25	32?	78	50	125	11	...	127	13	
10	444	450	44	27	25	Yes	71	24	39	61	44	100	15	64	125	13	
11	443	448	43	27	31	,,	73	27	31	87	58	132	−8	62	118	10	
12	403	407	41	25	24	,,	67	25	35	71	55	137	28	57	127	9	
13	409	413	44	27	27	,,	69	26	33	79	58	141	30	55	119	12	
14	386	389	41	27	26	No	68	26	33	79	56	144	10	49	122	10	
15	444	447	43	31	31	Yes	69	27	37	73	58	132	12	57	120	12	
16	425	429	44	29	31	,,	68	29	34	85	53	126	17	60	126	14	
17	388	390	40	25	28	,,	...	27	29	93	45	115	22	55	121	9	
18	422	424	43	27	29	,,	65?	26	34	76	52	124	25	56	126	17	
19	443	451	42	28	28	,,	70	27	35	77	55	125	20	53	122	11	Groove outside gluteal ridge.
20	439	442	44	28	31	No	70	25	34	73	57	129	20	57	129	10	
21	411	414	44	31	27	Yes	68	26	38	68	50	122	15	62	118	16	
22	434	439	43	28	29	,,	71	27	34	79	53	123	10	57	118	14	
23	428	433	45	25	29	,,	67?	26	31	84	57	133	22	62	130	12	
24	410	415	39	26	28	No	63	21	33	63	56	137	12	51	121	11	Arthritis at lower end.
25	400?	...	42	25	26	Yes	...	24	29	83	...	...	...	59	129	...	
26	414	422	42	27	25	,,	63?	23	29	79	53	129	−12	57	131	10	
27	410	414	43	25	25	No	67	27	36	75	52	125	24	55	122	11	Slight third trochanter.
28	428	431	43	27	25	Yes	70	25	34	73	49	114	26	58	129	11	
29	439	442	41	27	30	...	69	25	35	71	59	134	26	57	130	9	
30	420	421	44	26	29	Yes	70	27	33	82	46	110	30	55	127	10	
31	395	397	41	26	28	...	68	27	33	82	54	138	22	58	125	12	
32	453	463	43	26	32	No	68	27	35	77	60	133	30	61	125	13	Arthritis at lower end. Large bony boss in external supracondylar ridge.
33	443	443	42	30	24	,,	...	25	39	64	47	107	−5	59	118	2	
34	391	394	40	27	29	Yes	66	27	33	82	56	144	1	59	122	11	
35	439	442	39	24	27	...	65	26	31	84	60	136	32	56	130	9	Slight groove outside gluteal ridge.
36	398	407	43	26	29	No	67	27	36	75	56	140	14	57	128	16	
37	408	414	41	24	26	Yes	67	...	...	...	50	122	20	53	122	12	
38	408	411	43	25	26	...	69	26	29	90	57	139	12	55	122	11	
39	416	420	41	30	29	...	68	28	38	74	56	133	19	57	124	12	
40	394	399	37	25	25	No	60	22	32	69	48	125	10	53	133	14	
41	407	410	46	27	33	Yes	67	28	38	74	58	141	15	55	120	12	
42	409	411	40	27	25	,,	69	24	34	71	55	134	17	61	125	11	
43	422	424	42	26	28	...	65	24	30	80	52	124	15	58	125	9	Slight osteo-arthritis of lower articulation.
44	425	435	42	29	28	No	65	26	35	74	57	136	18	57	126	14	
45	409	411	41	27	28	,,	69	25	33	76	57	139	20	56	128	10	
46	385	391	41	26	26	Yes	65	23	30	77	58	153	23	50	118	13	
47	431	434	42	29	27	No	67	24	37	65	48	112	2	56	129	10	
48	421	422	41	26	30	Yes	66	27	33	82	51	121	10	59	132	8	
49	399	401	40	26	28	...	64	25	32	78	52	130	4	52	127	10	
50	403	405	46	27	27	Yes	64	27	35	77	58	145	4	58	123	9	
51	398	405	...	25	26	,,	...	23	29	79	51?	128	18	56	129	12	
Average	mm. 418 (51)	mm. 422 (49)	mm. 42 (48)	mm. 27 (51)	mm. 28 (51)	Present in 67%	mm. 67 (46)	mm. 26 (50)	mm. 33 (50)	79 (50)	mm. 54 (50)	129 (50)	° 16 (50)	mm. 57 (49)	° 125 (51)	° 11 (49)	

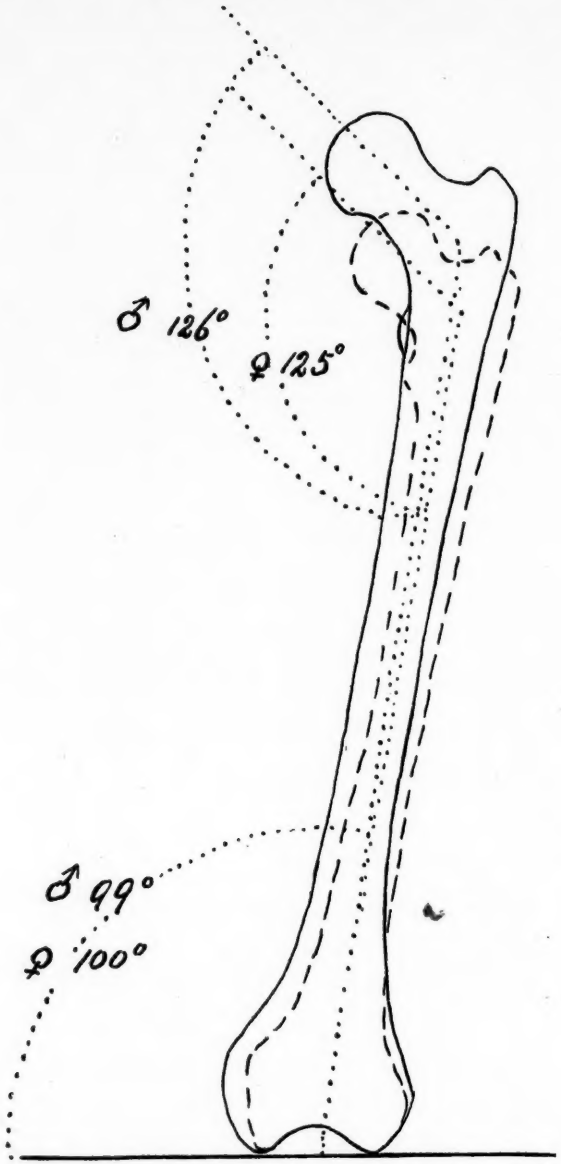


FIG. 4.—Left ♂ and ♀ femurs from Rothwell. (Type contours of 97 ♂ and 49 ♀ bones.) $\frac{1}{3}$ nat. size.

The average maximal length of the right female Rothwell femurs is 416 mm. and the left 422, giving an approximate stature of 160 cm., or 5 feet 3 inches, for the women.

I am only able to check Pearson's chart to a very small extent, but I have the measurements of 21 male femurs removed from bodies the stature of which was known. By Pearson's chart the average height of the 21 men should have been 5 feet $5\frac{3}{4}$ inches, and their actual average was 5 feet $5\frac{4}{5}$ inches. I do not think that we can hope for much greater accuracy than this. I do not know what the actual average of the present-day lower orders is, though the late Mr Gray told me that he believed it to be 5 feet 6 inches. Pearson finds the average of 1000 middle-class English males is 5 feet 10 inches, while 100 of my own students average 5 feet 9 inches. There does not, therefore, seem to be any reason to believe that the English race has grown smaller since the fourteenth and fifteenth centuries, while numerous measurements of Saxon femurs convince me that the males of this race averaged rather less than 5 feet 6 inches.

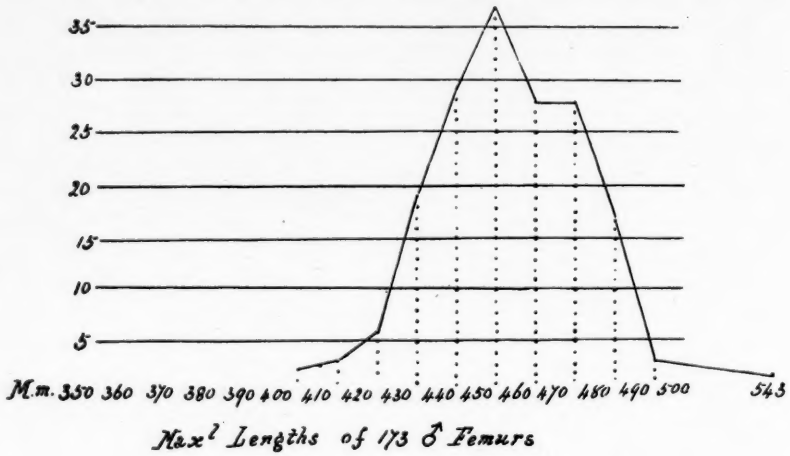
It is, of course, not enough to give the average lengths in the two sexes without considering the range of variation, and this I have endeavoured to do in the accompanying curves (fig. 5).

The diameter of the head is one of the most useful indications we have of the sex of a skeleton, because it is almost always available, while the pubic portion of the pelvis is one of the first parts to be disintegrated. Dwight (*American Journal of Anatomy*, vol. iv., No. 1, p. 19) gives measurements of 200 male and 200 female American bones in the recent state, and of the 200 male only 4 had femur heads less than 45 mm. in diameter. In the females 16 are over 47 mm., so that if we find a bone with a diameter of less than 45 mm. for the head it is almost certainly female, while a head of over 47 mm. will be that of a male 92 times out of a hundred.

In sexing these Rothwell femurs, therefore, I have paid special attention to the size of the femoral head, but where this measurement came between 45 and 47 mm. I have been specially careful to attend to other points, such as length, thickness, and width of lower end. Often this examination was quite enough to convince me of the sex, but still it is quite possible that a small percentage of the bones I have regarded as male are really those of females, though I do not think it at all likely that I have included more than one or two male bones among the female.

It will be seen from my tables that in 174 male (as I judge them) subjects (98 left and 76 right) the average diameter of the head is 49 mm., and this agrees closely with Dwight's record, for he found that in 200 cases

the average was 49·68 mm. I have not gone into fractions of a mm., as I consider it an unnecessary refinement, but, since his average is over 49·5, I should have reckoned it as 50 mm. This slight discrepancy is no doubt



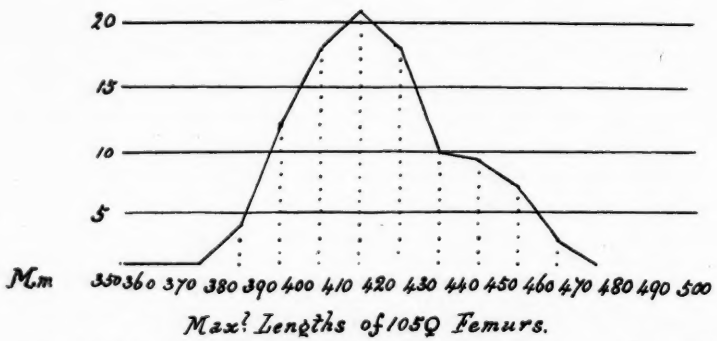


Fig. 5 —Range of variation in the maximal lengths of femurs of both sides from Rothwell.

accounted for by his examining the bones with the cartilage present, while in mine, which were mediæval bones, the cartilage was absent.

In the female Rothwell bones 48 of the left side gave an average of 42 mm., while in 55 right it was 44 mm. Dwight found that in 200 female femurs of which the side is not stated the average was 43·84. In my 103 bones of both sides the average is 43·4 mm., and no doubt the presence of

the cartilage largely accounts for the slight discrepancy. On the whole, I am pleased to see how substantially my work confirms Dwight's researches.

The smallest male femoral head in my Rothwell series was 45 mm., the largest 55 mm. I have been able to measure the femoral heads of 31 male and 11 female bodies from the dissecting-rooms of Guy's and St Thomas's Hospitals, and find that all the males were over 45 mm. with the exception of one head on the right side, which was 44 mm., but on the left side of the same body the head measured 46 mm. The average of each side in the males was 49 mm. The smallest female (as I judge it) femoral head from Rothwell was 36 mm., the largest 48 mm.

The least transverse diameter of the shaft is usually a little below the middle, and in male bones averages 30 mm. on the left side and 29 on the right. I have not much at present with which to compare this, but I found that in 8 right Anglo-Saxon male bones the diameter was 28, while in 10 left bones the measurement was the same. This number is probably a small one on which to generalise; but, as far as it goes, it shows that the Saxons were of a slighter build than were mediæval Englishmen. In 31 male bodies from Guy's and St. Thomas's the width of the right femora averaged 28·5 mm. while that of the left was 28·7 mm. In the Rothwell series the left female bones were 27 mm. and the right 26 mm. in breadth, so that in both sexes the left bones were stouter than the right.

In the Saxon female femora there were 6 right and 7 left, and in both the average diameter was 25 mm. (see "Saxon Bones from Folkestone," *Journ. R. Anthrop. Inst.*, vol. xli., 1911, p. 101).

The range of variation at Rothwell is for male bones 24 mm. to 35 mm., for female 21 mm. to 31 mm.

The greatest antero-posterior diameter of the shaft is for the male bones 32 mm. on the left and 31 mm. on the right. In the female it is 28 mm. on both sides.

The facet in front of the neck (see fig. 1) is sometimes covered with cartilage, but at others a rough depression. It is present in 79 per cent. of male bones on each side, while in female bones it is present in 67 per cent. on the left and in 58 per cent. on the right. It is curious that though it is so often present, it is seldom noticed in text-books. In my opinion this facet or depression is just as often present in modern bones as in mediæval or prehistoric, and I cannot believe that it is of the least value as an indication that its possessor was in the habit of squatting, since, in order to get the facet in contact with the margin of the acetabulum it is necessary to flex strongly and rotate internally the thigh. This internal rotation would keep the heels far apart in squatting instead of allowing them to touch; moreover, it is absurd to think that the majority of modern English

dissecting-room subjects were in the habit of adopting the squatting position.

The transverse diameter of the lower end of the femur, taken in the manner I have already described (see fig. 2), averages 77 mm. for left male femurs and 75 mm. for right, while in females it is 67 mm. for left and 68 for right.

There seems to be a general, though by no means absolute, ratio between the diameter of the head and that of the lower end, as the following table shows.

Sex.	No. of Observations.	Diameter of Head.	Average Diameter of Lower End.
		mm.	mm.
♀	1	36	63
,,	1	37	60
,,	3	39	64
,,	8	40	67
,,	14	41	66
,,	12	42	67
,,	18	43	69
,,	12	44	68
,,	12	45	70
,,	4	46 and over	68
♂	8	45	74
,,	8	46	74
,,	29	47	74
,,	17	48	78
,,	31	49	77
,,	19	50	76
,,	13	51	79
,,	10	52	78
,,	6	53	78
,,	8	54	83
,,	2	55	82

From the accompanying chart (fig. 6) it will be seen that a femur with a lower-end breadth of 71 or 72 mm. may be of either sex; above 72 it is probably male, below 71 probably female. It is useful to have been able to show that the head-breadth only varies more or less directly with that of the lower end, so that in many femurs in which the measurement of one articular end is negative the other will give a definite clue to the sex.

Platymeria.—As I have said, I do not know that there is any definite index below which a femur may be called platymeric; but to my eye one with an index below 75 attracts attention, and if this be taken as the dividing line, the following results are obtained:—

Out of 105 left ♂ femurs the average index was 81, and of these 9 (8·6 per cent) were below 75, *i.e.* platymeric.

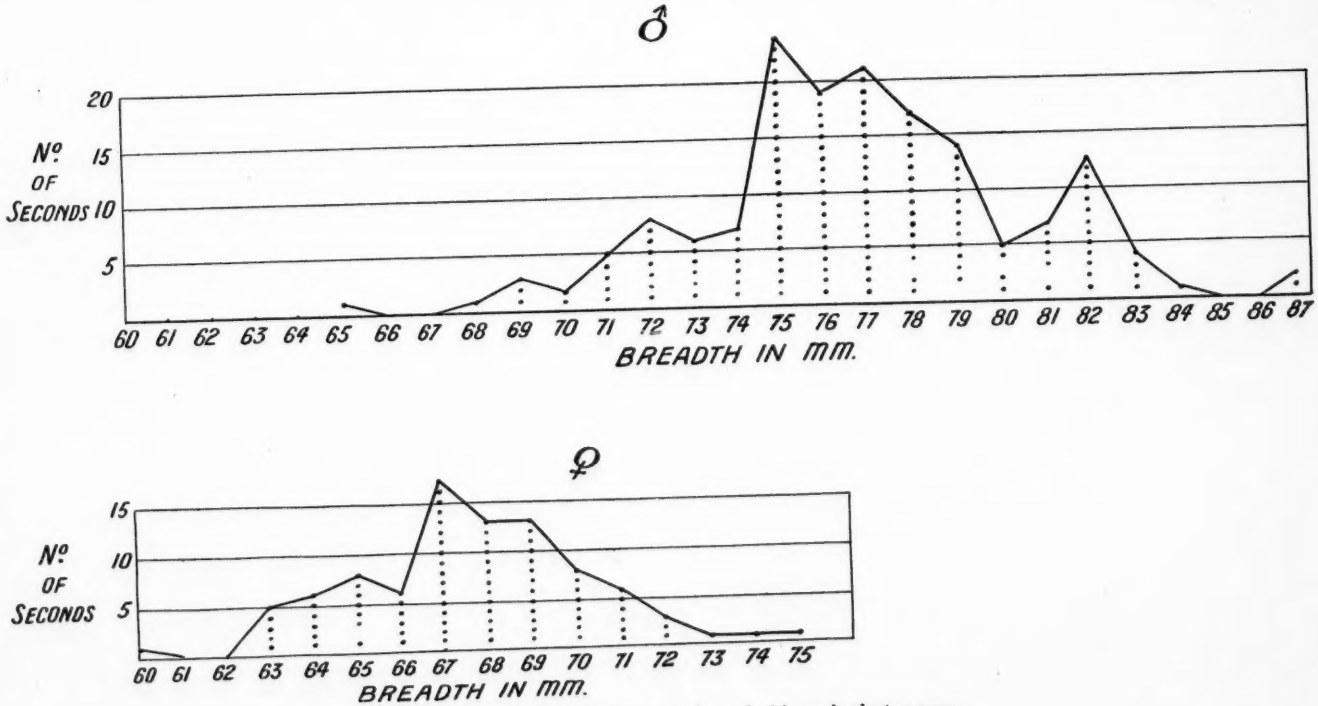


FIG. 6.—Chart of breadth of lower articular end of femur in the two sexes.

Out of 80 right ♂ bones the average index was 77, of which 12 (15 per cent.) were below 75.

Out of 50 left ♀ with an average index of 79, 17 (34 per cent.) were below 75.

Out of 55 right ♀ bones with an average index of 78, 12 (22 per cent.) were below 75.

The average index of the 185 ♂ bones of both sides was 79, while that of the 105 ♀ bones of both sides was 78.

Taking this last paragraph alone, it does not look as if sex made much difference to platymeria, but the foregoing paragraphs show that in the 185 male bones 11·4 per cent. were below the 75 index, while in the 105 females 27·6 were below. This is so marked a difference that I cannot help thinking that platymeria must have been commoner in women than in men

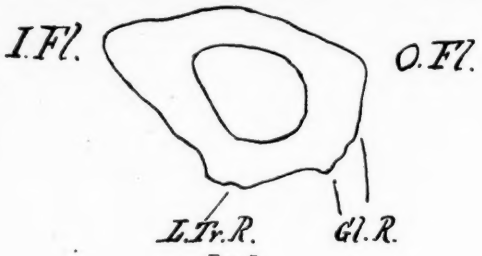


Fig. 7.

at Rothwell—a fact which is directly opposed to Manouvrier's experience, and one which shows that further research on this point is necessary.

The section shown in fig. 7, from a platymeric femur with an index of 63·5, indicates that four ridges are present: (1) the inner flange (I.Fl.), where the strongest pull of the vastus internus comes; (2) the outer flange (O.Fl.), where the vastus externus is most strongly attached; (3) the gluteal ridge (Gl.R.), marking the insertion of the gluteus maximus muscle; and (4) the lesser trochanteric ridge (L.Tr.R.), running from the lesser trochanter to the linea aspera. In most cases the inner flange is better developed than the outer, but occasionally the reverse is the case, as in fig. 8, B. It must be remembered that the fibres of the vasti run obliquely forward and downward from these ridges to the quadriceps extensor tendon, while the fibres of the gluteus maximus run inward and upward from the gluteal ridge, so that it is extremely unlikely that there is any good reason for accepting the suggestion that the latter muscle has anything to do with the production of the outer flange; moreover, fig. 8 shows that the two flanges may reach their maximum some distance below the region of the lesser trochanter and the

insertion of the gluteus maximus. Another point is that in these platymeric femora the great trochanter and spiral line are often drawn forward, apparently by the traction of the upper and strongest attachment of the crureus.

To my mind, everything which I have seen in connexion with platymeria points to the action of the vasti as its cause.

I believe that the Rothwell people were more platymeric than are modern Englishmen for the following reason. Through the kindness of my anatomical colleagues at Guy's Hospital I have been able to examine the right

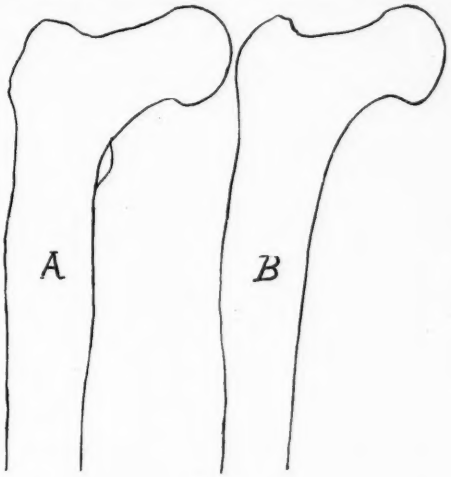


Fig. 8.

femurs of 27 subjects in that hospital and at St Thomas's; the average platymeric index of these was 83, while in 26 left femurs the index was 86.

The following comparison may be instructive:—

Male Platymeric Indices.

	Right.	Left.
Jutes from Folkestone	79 (8)	79 (4)
Mediæval English from Rothwell . . .	77 (80)	81 (105)
Modern English from Guy's and St Thomas's Hospitals	83 (27)	86 (26)

The number of Jutes (in brackets) is too small to generalise upon; but, taking them for what they are worth, it looks as though the same cause which produced platymeria in these early English was operative in the mediæval English of the fourteenth century and is not nearly so active now.

The above table also seems to show pretty conclusively that platymeria is and was more marked on the left side than the right.

Antero-posterior bowing of the femur.—The following table shows the average amount of actual bowing of the femur measured by the method described on p. 241:—

		Maximal.	Minimal.
	mm.		
75 R. ♂ . . .	61	75	53
95 L. ♂ . . .	62	78	47
54 R. ♀ . . .	56	65	45
50 L. ♀ . . .	54	63	44

The index of bowing, which shows the amount in proportion to the length of the bone, is—

		Maximal.	Minimal.
75 R. ♂ . . .	135	170	117
95 L ♂ . . .	135	171	104
170 both sides ♂ . .	135		
54 R. ♀ . . .	137	162	107
50 L. ♀ . . .	129	154	100
104 both sides ♀ . .	133		

It is usually held that the shortest femora are most liable to bowing, and this is borne out in this collection, because I find that the 12 actually most bowed femora average 3 mm. below the average length, while 24 relatively most bowed average 5 mm. below.

Again, the 21 longest femurs in the collection are less bowed than the average in the proportion of 129 to 135.

The angle which the axis of the neck makes with the long axis of the shaft is as follows:—

	Average.	Maximal.	Minimal.
79 R. ♂ . . .	127°	140°	113°
104 L. ♂ . . .	126°	138°	112°
54 R ♀ . . .	126°	133°	114°
51 L. ♀ . . .	125°	133°	118°

From this it is evident that the angle of the neck is of no value as an indication of sex.

It is usually held that the longest femurs have the most vertical necks. To test this, I took the 18 right femurs which had a maximal length of over 470 mm., and found that the average angle of their necks was 127°, which is the average for the right side, so that the result is negative; but on picking out the 11 femurs of both sides which have an angle of 135° and over, I find that their average length is 466 mm. against a general average of 458. It therefore seems probable that the femurs with the most vertical necks are the longest, though it does not seem correct to say that the longest femurs have necessarily the most vertical necks.

The length of the neck, measured as directed on p. 241, gives the following results:—

	Average.	Maximal.	Minimal.
	Mm.		
78 R. ♂ . . .	65	86	55
102 L. ♂ . . .	66	83	55
54 R. ♀ . . .	56	63	49
49 L. ♀ . . .	57	64	49

The two maximal lengths of 86 mm. on the right side and 83 on the left were so phenomenal that I have gone over all their other measurements

FIG. 9.

with great care, in the hope of finding some other characteristic correlated with length of neck; but I have been unable to find any clue to the meaning of this curious abnormality, which in the case illustrated by a dioptographic tracing in fig. 9 amounts almost to a deformity. That the two bones

(L. ♂ No. 63, and R. ♂ No. 27) did not come from the same individual is quite clear from the difference in their lengths.

Hirsch (*Anatom. Hefte*, Bd. xxxvii., 1899) states that a long neck to the femur is accompanied by a high angle of the neck, and a short neck with a low angle. To test this, I worked out the average of the angle of all those femurs whose neck was above the average length as well as of all those in which the neck was the average length or below—with the following results:—

	Average Angle.
51 ♂ left femurs whose neck was over 65 mm. (average) .	126°
51 „ „ „ „ „ 65 mm. or below .	124°
37 ♂ right „ „ „ over 65 mm. (average) .	128°
46 „ „ „ „ „ 65 mm. or below .	126°
18 ♀ left „ „ „ over 57 mm. (average) .	125°
31 „ „ „ „ „ 57 mm. or below .	125°
25 ♀ right „ „ „ over 56 mm. (average) .	125°
30 „ „ „ „ „ 56 mm. or below .	126°

As far as these English femurs go, therefore, the males bear out Hirsch's contention: the necks above the average length have on each side a wider angle by 2° than the average necks or those below the average. In the female bones, however, there is practically no difference in the angle of the long and the short necks.

The degree of torsion of the shaft, measured as described on p. 241, gives the following results:—

	Angle of Torsion.	Maximal.	Minimal.
69 R. ♂ . . .	13°	30°	−13°
98 L. ♂ . . .	13°	40°	−17°
49 R. ♀ . . .	18°	34°	+ 2°
50 L. ♀ . . .	16°	32°	−12°

This table points to the female bones being more twisted than the male. I cannot find, however, that length by itself is correlated in any way with torsion, because I have picked out all the femurs with a torsion above and below the average, and find that their average lengths vary hardly at all from the normal.

The point which has struck me most is the enormous range of variation in the twisting of the femur, and that in a certain number of cases the lower end is actually twisted outward instead of inward—in one case to the amount of 17° (see fig. 10).

I cannot find, after going over my material carefully, that excessive torsion is correlated with any other constant physical characteristic of the femur, though it may well be with that of some other part of the skeleton.

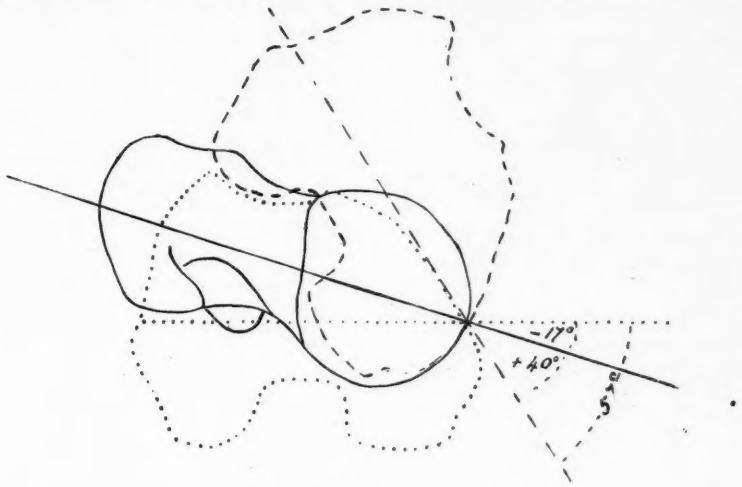


FIG. 10.

It is something, however, to have demonstrated what a great range of variation is possible.

The obliquity of the shaft, measured as described on p. 242, gives the following results:—

	Average Obliquity.	Maximal.	Minimal.
71 ♂ R. . . .	9°	17°	4°
97 ♂ L. . . .	9°	14°	5°
49 ♀ R. . . .	10°	14°	5°
49 ♀ L. . . .	11°	17°	2°

From this it appears that the female femur is one or two degrees more oblique than the male, but it is obvious that the amount of obliquity would be of no use in determining the sex of any particular bone.

Other things being equal, one would expect that the shorter bones would be more oblique than the longer, though the breadth of the pelvis, the length of the neck, and the angle of the neck would be disturbing factors.

To test this theory, I picked out the 82 male femora of both sides in

which the obliquity was more than 9° (the normal), but to my surprise their average maximal length was 456 mm., against the normal for all male femora of 458 mm. I am therefore compelled to believe that the disturbing factors above mentioned must play a more important part than I had thought

Of these I was able to check the length and obliquity of the neck, but not the breadth of the pelvis, and I therefore took 79 of the 82 male femora above mentioned, to see whether the average length of their necks was greater than the normal. I could not take all the 82, because in 3 of them the measurements were not all available.

In these 79 the average length of the neck was 65 mm., which is the normal for the whole male series; while the average angle of the neck was 126°, which, again, is practically the normal, so that the result of this work was negative, and I have no reason to believe that in a large series special obliquity of the femur is associated with (1) diminished length of shaft, (2) increased length of neck, or (3) diminution in the angle of the neck. It is, therefore, presumably associated with increased breadth of pelvis, and this is the more likely since the obliquity is greater in the female than in the male bones.

The next point upon which I want some definite information is the number of observations upon which one may venture to generalise.

In working through a Saxon or Bronze Age burial-ground one sometimes finds that perhaps only 10 femurs are available for measurement on the right side or the left. How far is one justified in deducing the average stature of the tribe or race from 10 femurs?

To get some working idea of this, I have divided my measurements of the maximal femur lengths into segments of 10 as they came, and have taken the average of each 10, and noticed how far it departed from the average of all the bones, with the following results:—

In the left male femurs at Rothwell the average length of 98 bones was 460 mm. Of these—

The 1st	10	averaged	474,	or	14	above	the general average.
„ 2nd	„	„	472,	„	12	„	„ „ „
„ 3rd	„	„	462,	„	2	„	„ „ „
„ 4th	„	„	459,	„	1	below	„ „ „
„ 5th	„	„	455,	„	5	„	„ „ „
„ 6th	„	„	467,	„	7	above	„ „ „
„ 7th	„	„	445,	„	15	below	„ „ „
„ 8th	„	„	457,	„	3	„	„ „ „
„ 9th	„	„	456,	„	4	„	„ „ „

In the right male femurs the average length of 76 bones was 456 mm. Of these—

The 1st 10 averaged	459,	or	3	above	the	general	average.
„ 2nd „ „	463,	„	7	„	„	„	„
„ 3rd „ „	461,	„	5	„	„	„	„
„ 4th „ „	460,	„	4	„	„	„	„
„ 5th „ „	452,	„	4	below	„	„	„
„ 6th „ „	459,	„	3	above	„	„	„
„ 7th „ „	443,	„	13	below	„	„	„

In the left female femurs the average length of 49 bones was 422 mm. Of these—

The 1st 10 averaged	432,	or	10	above	the	general	average.
„ 2nd „ „	421,	„	1	below	„	„	„
„ 3rd „ „	428,	„	6	above	„	„	„
„ 4th „ „	415,	„	7	below	„	„	„

In the right female femurs the average maximal length of 53 bones was 416 mm. Of these—

The 1st 10 averaged	428,	or	12	above	the	general	average.
„ 2nd „ „	433,	„	17	„	„	„	„
„ 3rd „ „	419,	„	3	„	„	„	„
„ 4th „ „	415,	„	1	below	„	„	„
„ 5th „ „	411,	„	5	„	„	„	„

From this I gather that if these bones had come to me in groups of 10 I should probably have over- or under-estimated their average length by about 7 mm. on an average. In 13 of the 25 groups of 10 I should have been within 5 mm. of the general average, but in 1 group I should have been out by 17 mm.

A mathematician would no doubt state the case much more satisfactorily, but I fancy that the above method gives the field or charnel-house worker a fair idea of this position, since the greatest error, that of 17 mm., when applied to Pearson's tables (*Phil. Trans.*, vol. excii. pp. 169–244) only makes a difference of 2 cm. in the average height of the group.

I cannot help believing that one would be quite justified in estimating the height of a race to within an inch on the evidence of 10 femurs, provided their lengths were accurately taken, though no doubt a series of 20 or 30 would be more desirable.

In other measurements, such as those of the diameter of the head or the breadth of the lower end, where the range of variation is less, the evidence of 10 femurs would be more reliable still.

Summary.

1. In the thirteenth, fourteenth, and fifteenth centuries the Midland English, on the evidence of 300 of their thigh-bones, had an average stature of 5 feet 5¾ inches for the men, and 5 feet 3 inches for the women.

2. No absolute information can be drawn from the Rothwell series as to the sexual value of the diameter of the head, since the sex of the bones was unknown and was largely determined by the size of the head. The sexing was done on the evidence of Dwight's observations in New York, checked by my own records of 42 modern English femurs the sex of which was known. When the head is more than 47 mm. in diameter, it is regarded as male; when below 45 as female. Between these measurements the length, thickness of shaft, and width of the lower end are taken into account, and in this way the error of sexing is probably so small as to be negligible in a large series

3. The left femur, both in males and females, averages 3 mm. more in its oblique length than the right.

4. There is an average difference of 3 mm. between the maximal and oblique lengths, but there is a range of variation from 0 to 11 mm.

5. Speaking generally, the greater the obliquity of the femur, the greater is the difference between the oblique and maximal lengths.

6. In the Rothwell bones, as in those of modern English people, the diameter of the head of the male femur averages 49 mm., while that of the Rothwell females is 43·4 mm.

7. The width of the lower end of the femur forms a valuable clue to the sex in many of those cases in which the diameter of the head is negative or impossible to obtain. A breadth of 71 or 72 mm. may be of either sex. Below 71 it is probably female, above 72 probably male.

8. At Rothwell platymeria is quite common, but is much less so in modern English femurs; it is commoner here in women than in men, and is more marked on the left side than on the right.

9. The amount of antero-posterior bowing of the shaft is greater in short bones than in long; the index is also slightly greater in male than in female bones.

10. The angle of the neck seems a trifle (1°) less on the left side than on the right, and also about 1° less in females than in males. Femurs with very vertical necks are usually the longest.

11. In the male femurs those with necks above the average length have a more open angle to the neck by 2° than those with necks of the average or below the average length. In the females there is no appreciable difference.

12. The pressure facet on the front of the neck was present in over three-quarters of all male, and in over half of all female bones. It seems quite as common in modern dissecting-room bones, and, since I have no reason to believe that it is associated in these latter with a squatting posture, I am disinclined to regard it as the result of squatting in ancient bones.

13. The amount of torsion of the shaft of the femur is very variable, but appears to be greater in women than in men. In a certain number of cases there is an external instead of an internal twist of the lower end of the bone.

14. The female femur is 1° or 2° more oblique than the male. The amount of obliquity does not seem to vary with the length of the bone, the angle of the neck, or the length of the neck. It is possibly associated with the breadth of the pelvis, though I cannot check this in this research.

15. It seems possible to estimate the size of a race to within an inch from the lengths of 10 femora, though doubtless a greater number is desirable.

Finally, I should like to call attention to a small prominence on the popliteal surface of the femur a little above the internal condyle. I have not hitherto seen it described, though it is usually to be found if looked for. I believe that it is caused by the pull of the uppermost fibres of the inner head of the gastrocnemius. In one specimen from the dissecting-room of Guy's Hospital it was of great size, and the records of abnormalities, which at this hospital are very accurately kept, show that the inner head of the gastrocnemius was larger than usual and rose from the eminence. The point is of some slight interest in showing that, although this muscle rises chiefly from the epiphysis of the femur, some of its fibres extend up to the diaphysis.

THE LOWER ENDS OF THE WOLFFIAN DUCTS IN A FEMALE PIG EMBRYO.

By FREDERIC WOOD JONES, D.Sc., *The London School of Medicine for Women.*

THE present communication is intended to deal with a mere presentation of the conditions that are actually illustrated, and, like a previous communication on the External Genitalia of the Human Female (*Jour.*, xlviii. p. 73), is to be regarded only as an isolated study carried out as part of a wider survey of the mammalian genitalia. The sections which are illustrated were cut some ten years ago. The facts which they illustrate are by no means new, but I think it is advisable to record them as showing a definite phase in the evolution of the genital ducts in the pig. The stage recorded and illustrated is that found in fœtuses of 12 centimetres rump-vertex length. The series of sections is shown in order from head to tail, and the photographs represent on the average every fifth section of the series.

In the most cephalad sections (see figs. 1 and 2) the fused Müllerian ducts have constituted a wide and patent canal (vagina, fig. 1), seen upon the dorsal side of the section, and towards the ventral side of the section is the cavity of the urethra, both chambers being surrounded by a well-defined common musculature.

Upon the ventral aspect of the fused Müllerian ducts, and embedded in their mesenchyme stroma, are the minute Wolffian ducts (W.D.).

As the sections are traced towards the caudal end, the lumen of the Müllerian ducts diminishes and becomes again bilateral by the closure of the central part of the canal (see fig. 3). After a short distance traversed in this fashion, even the bilateral Müllerian elements become reduced to solid columns of cells (see fig. 4).

Meanwhile the lumen of the Wolffian ducts is becoming increasingly large.

Still further towards the hind end the solid Müllerian columns become difficult to trace, and are closely applied to the dorsal aspects of the ever-enlarging Wolffian ducts (see figs. 5 and 6).

In the section represented in fig. 7, the two enlarged Wolffian ducts have met and fused in the middle line, forming a single median Wolffian chamber; and the Müllerian elements have become still further reduced.

Finally, in the section shown in fig. 8, the Wolffian chamber has opened into the urinary canal, forming a uro-genital sinus.

I think it is not unreasonable to interpret the condition shown as being a definite phase in the development of the female pig embryo, in which the Wolffian ducts are the only genital channels opening into the uro-genital sinus. In this phase the Müllerian ducts are reduced to solid epithelial cords, and the uterine cavity has no outlet into the uro-genital sinus. The single median genital opening is a Wolffian chamber into which apparently the Müllerian ducts will open when they become patent later on in fœtal life.

For the production of the microphotographs which illustrate this paper (pp. 270–273) I am indebted to the kind help and skilled assistance of the Anatomical Department of King's College.

[Figs. 1–8.

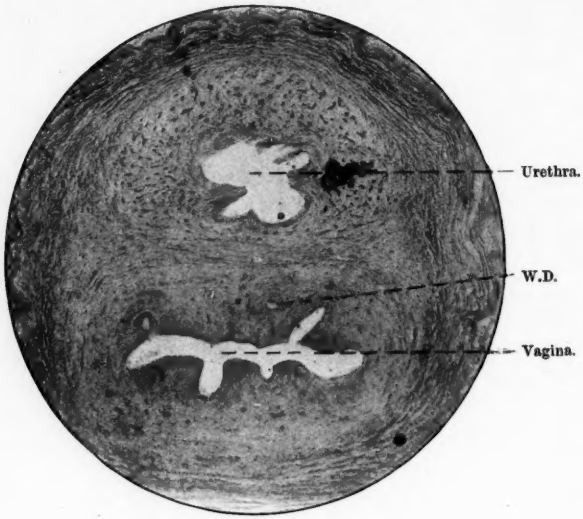


Fig. 1.

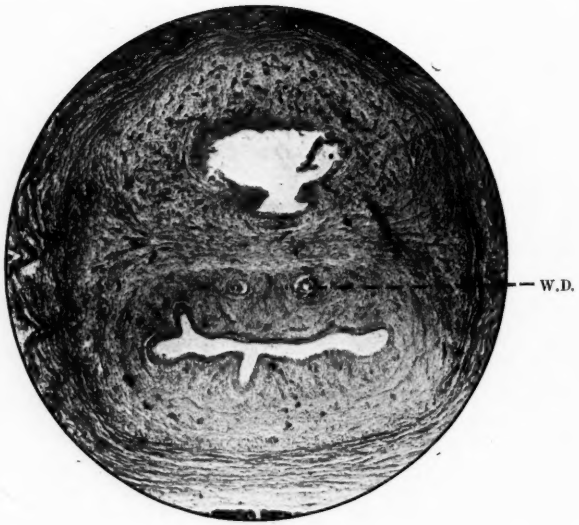


Fig. 2.

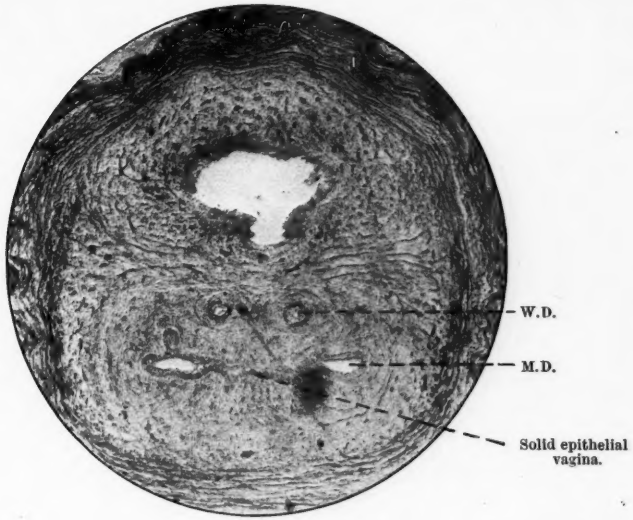


FIG. 3.

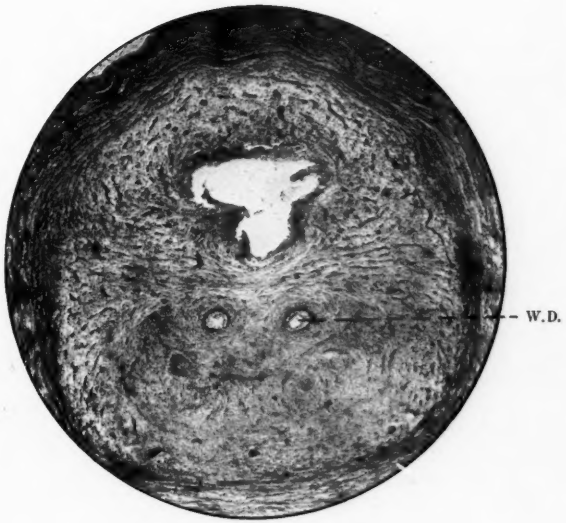


FIG. 4.

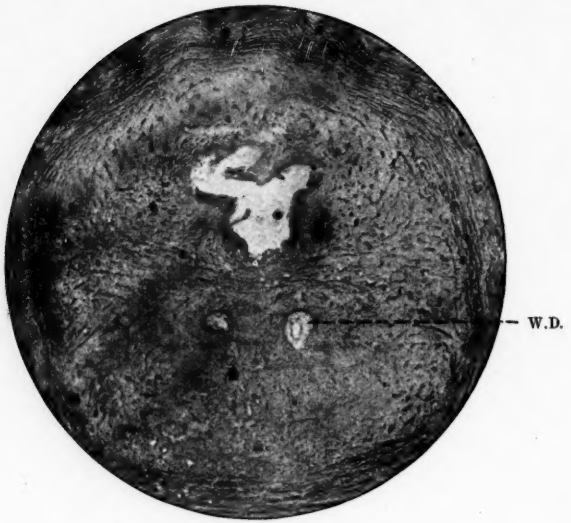


Fig. 5.

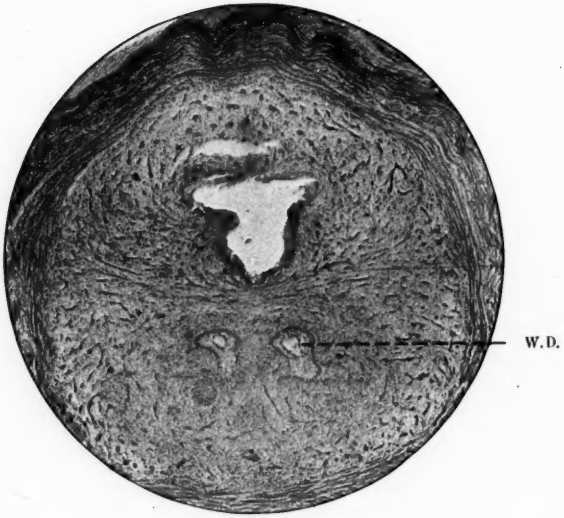


Fig. 6.

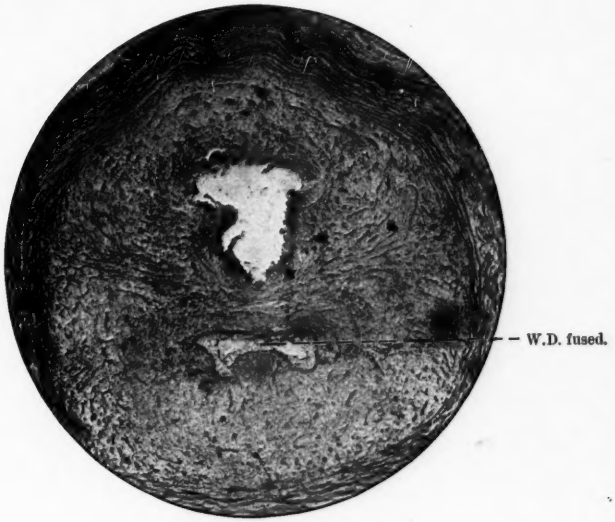


FIG. 7.

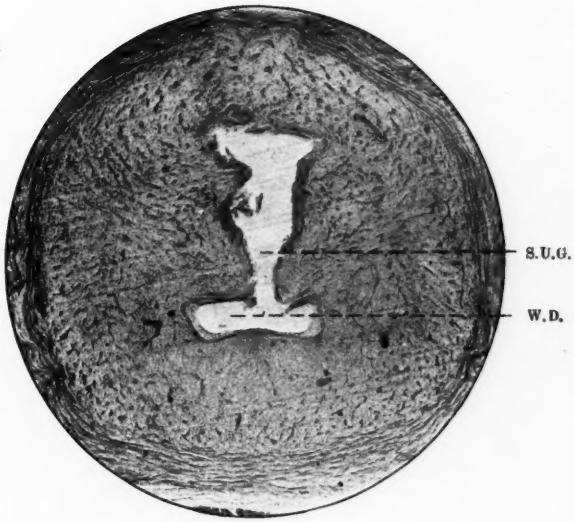


FIG. 8.

TWO CASES OF CARDIAC MALFORMATION—MORE ESPECIALLY OF THE INFUNDIBULAR REGION.

By D. Davidson Black, B.A., M.B. (Tor.), *Assistant Professor of Anatomy, Western Reserve University, School of Medicine, Cleveland, Ohio, U.S.A.*

The two specimens of malformed heart which form the subject of this communication are of interest in view of the recent work by Keith on the relation of cardiac malformation to the development of the heart (1), (2), (3). The present cases offer further examples of anomalous infundibular development.

Both cases came to autopsy at the Cleveland City Hospital, and I am indebted to Dr A. A. Johnston, resident pathologist, and Dr Harrison G. Wagner, upon whose service the patients were admitted, for the opportunity of examining the material.

Specimen I.—The specimen was obtained from a male negro, æt. 22, labourer, weight 130 lbs., height 5 feet 10 inches. A clinical diagnosis was made of pulmonary tuberculosis and congenital pulmonary stenosis. Chronic circulatory stasis was indicated by a condition of club-fingers and enlargement of the ends of the long bones. There was no sign of œdema to indicate cardiac failure. No cyanosis was observed, but this may readily have been overlooked on account of the patient's colour.

Description of Heart (fig. 1).—The organ as a whole is enlarged (weight 425 gms.). The right atrium is normal; the foramen ovale is patent to a considerable extent in its superior portion. The tricuspid valve shows several slight roughenings on its atrial surface near the free margin. The wall of the right ventricle is increased in thickness to 1·3 cm., and the infundibular portion is separated from the body of the ventricle, giving the heart the appearance of a triventricular organ. Communication is established between these two portions of the right ventricle by a well-marked ostium bulbi (1 cm. in diameter), and by several irregular openings towards the apical portion of the ventricle between the trabeculæ carneæ. These relations are shown semi-diagrammatically in fig. 1. The pulmonary artery, which arises from the infundibulum, is markedly stenosed in the region of the semilunar valve. The valve is formed of two modified cusps, which are thick and fibrous, and so united as to leave between them only a small slit-like opening 5 mm. in diameter (*v.* fig. 2). Above the level of

the valve the vessel is thin-walled and increased in diameter to 15 mm. The interventricular septum is deficient in its superior portion, giving rise to a large interventricular foramen situated immediately behind the septal cusp of the tricuspid valve.

The left mitral valve is normal. The left ventricle is also normal, with the exception of the foramen interventriculare already noted. The aorta, which is 25 mm. in diameter at its base, is somewhat smaller than normal, and is provided with a well-formed semilunar valve. The average diameter of the aortic base in the normal adult is 27–28 mm. (4 and 5). The relation of the coronary arteries at their origin is normal. The condition of the ductus arteriosus could not be determined, for the greater

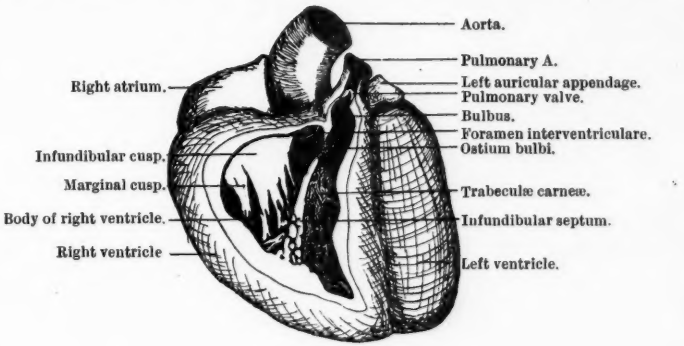


FIG. 1.

part of the pulmonary artery and aortic arch had been removed from the specimen, and no note regarding the ductus was made at autopsy.

The position of the foramen interventriculare is such that, owing to the stenosed condition of the pulmonary orifice, the major portion of the blood from both ventricles passed directly into the aorta. This relation of the base of the aorta to the interventricular septum and the ventricles is shown diagrammatically in fig. 2.

Of the nineteen hearts described by Keith (2) as having infundibular subdivisions of the right ventricle, in only one case did the infundibular chamber reach the apex of the organ. In the present case, the infundibular cavity extends to the apex, and although there is a partial communication between the body of the right ventricle and the apex of the infundibulum through the meshes of muscular trabeculæ, yet the division between the two chambers is obvious.

The infundibular septum is wholly muscular in the case under discussion,

and the ostium bulbi is guarded by an incomplete fibrous ring on the ventricular side. This orifice is situated immediately in front of the interventricular foramen. In most of the cases described by Keith which showed almost complete suppression of infundibular development with consequent pulmonary stenosis, the branches of the pulmonary artery were very thin-walled and frequently much enlarged in diameter. A similar enlarged condition of the pulmonary trunk obtains in the present case. In 70 per cent. of Keith's cases, no patent ductus arteriosus was present. Thus, the increased diameter of the pulmonary vessel above the level of the semilunar valve cannot be considered as indicative of the presence of a patent ductus.

The presence of a large foramen interventriculare may be accounted for by the incomplete infundibular development. Keith (2) observes: "In the majority of such cases (85–90 per cent.) an interventricular foramen is

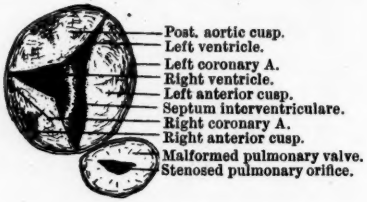


FIG. 2.

present." These facts support Hunter's view that pulmonary obstruction is the essential factor preventing closure of this foramen. Indeed, it would be difficult to imagine the attainment of adult life by an individual whose heart presents an advanced condition of pulmonary stenosis, accompanied by a well-developed right ventricle, and yet exhibits no interventricular communication.

Specimen II.—The specimen was obtained from a male child, æt. 6 months, whose death was due to accidental causes. The case showed no evidence whatever of any cardiac insufficiency.

Description of Heart (fig. 3).—The right atrium is normal, and the fossa ovalis presents the normal small aperture at its superior margin. The tricuspid valve shows several slight roughened areas on the atrial surfaces near the margins of its cusps. The adjacent margins of the infundibular and septal cusps are adherent to the interventricular septum, and between these cusps is an opening (7 mm. in diameter) leading through the membranous portion of the interventricular septum into the left ventricle. The pulmonary artery, which appears enlarged, measures 12 mm.

in diameter at the semilunar orifice. The ductus arteriosus, which is 5 mm. in diameter, arises from the pulmonary artery at its bifurcation. The attachment of the ductus to the aortic arch could not be made out, as the latter had been removed from the specimen. The mitral valve is normal. The left ventricle is normal, with the exception of the foramen interventriculare already noted. This foramen is situated immediately below the origin of the aorta. The aorta measures only 8 mm. in diameter at the level of the aortic valves, and is thus barely more than two-thirds the diameter of the pulmonary artery. This is unusual, as the normal ratio between the diameter of the pulmonary artery and aorta in early life is 4 : 3. The walls and valves of the aorta are of normal texture. The origin of the coronary arteries is normal.

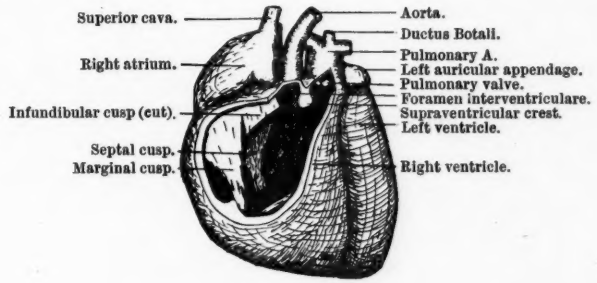


FIG. 3.

This specimen appears to be one of those rare cases in which there is no stenosis of the pulmonary artery or isolation of the infundibulum to account for the presence of the interventricular foramen. As in the similar cases recorded by Keith (2), the margins of the interventricular foramen are membranous. The relation of the tricuspid valve to this foramen is of interest. In the heart illustrated in fig. 3, the infundibular cusp is cut, otherwise the foramen could not be seen in the view represented.

The relations of the *supraventricular crest* point to its identity with Keith's *right infundibular band.* It certainly forms a distinct boundary between the bulbus and the body of the right ventricle. Notwithstanding the presence of a comparatively large interventricular foramen, the walls of the right ventricle are thinner than those of the left ventricle.

In the absence of stenosis in the aorta, the small diameter of the vessel is unusual. It may be that the persistence of the interventricular foramen is related in some way to the undersized aorta. In such a case the excess of blood not accommodated by the aorta in ventricular systole would

find vent through the interventricular foramen, and become one of the factors contributing to the increased size of the pulmonary artery.

Specimen II. is thus an example of a heart which presented several fundamental anomalies, and yet performed its function adequately. Its irregular structure had no bearing on the death of the individual.

It is a well-known fact that in cases of more or less prolonged respiratory embarrassment there is a marked tendency toward polycythæmia. Dixon Mann (6) has pointed out that the rise in the number of red corpuscles is apparently related to a decreased power of internal respiration. He further observes that any of the factors causing the latter condition may produce an increase in the number of red cells. In the congenital heart malformations under discussion, there is a free admixture of venous and arterial blood in the systemic arteries. In other words, these cases must have a decreased internal respiratory power, which demands a compensatory polycythæmia.

In the first case described in this paper, the red corpuscles were increased to 7,228,000 per cubic mm., and no observations were made as to cyanosis. In Case II., no cyanosis was present, but unfortunately no blood-count was made.

From the number of cases on record of patent interventricular foramen in which the patients showed but little if any signs of cyanosis during life, there can be no doubt that simple admixture of venous and arterial blood in the systemic arteries does not necessarily produce this condition. To quote Lorrain Smith (7): "In general, cyanosis is due to any cause which prevents due oxygenation of the blood." This must mean that, if the absolute quantity of oxygen in the blood falls below a certain minimum, cyanosis will result. The limit of the power of the organism to react successfully to the anomalous circulatory condition is thus marked by the appearance of cyanosis.

The question of tissue respiration and the relation of cyanosis to polycythæmia leads to an interesting line of inquiry regarding the evolution of the homoiothermic type of circulation.

Arrested development in a mammalian heart, allowing a free admixture of pulmonary and systemic blood in the systemic arteries, gives rise, physiologically at any rate, to a reptilian type of circulation. This circulation being unsuited to the needs of an homoiothermic animal, must be reinforced in some way in order to provide an oxygen supply sufficient to maintain life.

In the case reported by Dixon Mann (6), and also by Young (8), and Young and Robinson (9), there was a total lack of interventricular septum, and yet the patient lived to the age of 35 years, and showed no sign of

cyanosis till the last three weeks before his death, and but few signs of cardiac embarrassment during his life. Such a case demonstrates the ability of the mammalian organism to cope more or less successfully with a reversion to ancestral circulatory conditions.

Thus the mammalian organism reacts toward this condition of circulation in at least two ways: by reduction of the general activities, and by an increase in the number of oxygen carriers in the blood. It would be of interest to determine whether this latter reaction could be rightly considered as an ancestral reversion, and if so, whether, in the primitive homoiothermic forms, an increase in the number of oxygen carriers in the blood preceded the changes in the mechanics of circulation which result in the formation of the two-sided heart typical of birds and mammals.

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FIGURES RELATIVE TO CONGENITAL ABNORMALITIES OF THE UPPER URINARY TRACT, AND SOME POINTS IN THE SURGICAL ANATOMY OF THE KIDNEYS, URETER, AND BLADDER.

By Ralph Thompson, Ch.M., F.R.C.S., *Surgeon in Charge of Genito-Urinary Department, Guy's Hospital; Surgeon to the Victoria Hospital for Children.*

The facts to be recorded in this paper are gathered from the post-mortem records at Guy's and the London Hospitals, as well as those of the Victoria Hospital for Children. The Guy's records include the years from 1890 to 1909, the London Hospital 1909 and 1910, and the Victoria Hospital 1889 to 1912.

No reliance has been placed upon indexes, but each report has been carefully read through, in order to arrive at some definite conclusion with regard to the percentage of congenital defects and other lesions of the genito-urinary apparatus.

The total number of records consulted is 13,505, of which 8218 are males and 5287 females, or practically 10 males to 6·4 females. All the three hospitals showed the same proportion. It is important to bear these figures in mind when discussing the relative incidence of disease, or anatomical peculiarities, in the two sexes.

The paper deals especially with the incidence of congenital defects of the upper urinary tract. The frequency of disease in the right kidney, when compared with the left, is worthy of the closest attention; and it is plain that the anatomical differences which exist in the relations of the two kidneys may have something to do with this fact, which is now very generally recognised.

Finally, it is intended that attention should be drawn to a very important anatomical point in connexion with the bladder, which every anatomist probably knows, but which text-books either ignore, or upon which they give wrong advice.

The congenital defects of the upper urinary tract are considered under three headings, namely:—

1. Solitary kidney. 2. Horseshoe kidney. 3. Double ureter.

1. Solitary Kidney.

Figures with regard to solitary kidney vary very much. White and Martin give solitary kidney as occurring in 1 in 400 cases. Sir Henry Morris gives 1 in 4000. I strongly suspect that some of the figures given are based on very scanty evidence, such as is supplied, for example, by indexes of records. Be this as it may, the figures which are given here are as follows:—There are 23 cases of solitary kidney in the 13,000 odd reports consulted, or practically 1 in 587. Of these 23 cases, there were 14 males and 8 females, and 1 whose sex is unrecorded. Bearing in mind the preponderance of male post-mortem records over female, we see that the incidence of solitary kidney is practically equal in the two sexes.

Further details with regard to these cases of solitary kidney may be briefly summarised thus:—

Right kidney present	8
Left kidney present	13
Doubtful side	1
Sacral kidney present	1

Adrenals recorded as present in 6 cases.

Both testicles recorded as present in 3 cases.

Other abnormalities were noted as being present in 3 cases, viz.:—

Imperforate anus and deformity of lower limb	1
Four-lobed right lung	1
Right tube and ovary not connected with uterus; right kidney absent	1

In all cases the solitary kidney was larger than usual.

In 3 cases the solitary kidney was provided with two ureters, opening either together or separately at or near the bladder orifice.

In 4 cases the bladder ureteric outgrowth was present—patent for about an inch, and terminating in a fibrous cord.

A very interesting case of solitary kidney is that of a male child aged 6 weeks. The autopsy was performed by Professor H. R. Dean, at the Victoria Hospital. In this case there was a lobulated left solitary kidney, reaching as low as the bifurcation of the aorta, with three segmental vessels passing to the kidney from the left side of the aorta; and with two ureters, one from the front and upper part, and extending downwards in front of the organ to the pelvis, and another ureter passing from the lower and narrow end of the kidney. The upper ureter passed to the bladder and opened into that viscus in the usual position of the left ureter; the lower ureter cut across the bifurcation of the aorta lying superficial to that vessel,

and, passing into the pelvis, opened into the bladder in the position of the right ureter. Is this a double kidney? Is it a misplaced or displaced horseshoe kidney, or a single segmental kidney, or is there some deeper significance? I suggest, with deference and regard for the opinion of workers in this field, that it may be perhaps a condition allied to the descent of the testicle, which hears, as it were, the call of the mammary line and turns thither, and that the right ureter passing upwards heard no right renal call, but, determined to do its duty, was attracted by the left kidney, and passed across the middle line to join the left kidney.

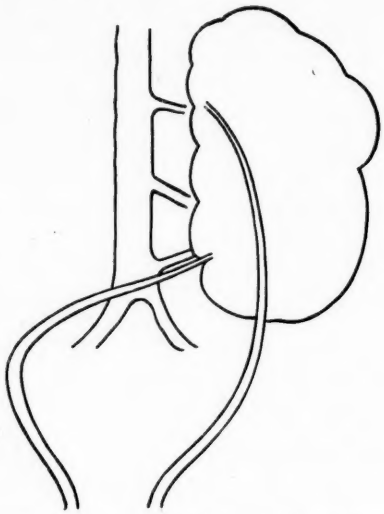

Diagram of case of solitary kidney with double ureter.

2. Horseshoe Kidney.

From the records of Guy's and the Victoria Hospital, comprising approximately 11,150 cases, there have been collected 16 cases of horseshoe kidney, or roughly 1 in 620 cases of all subjects. In this series males show a large preponderance over females—14 males to 1 female and 1 uncertain. I tabulate a brief summary:—

The concavity was directed upwards in 10 subjects.
" " downwards in 2 subjects.
Not recorded in 4 subjects.

A bridge of renal tissue is said to have existed in 5 subjects.

The ureters lay in front of the renal mass in 5 cases, and in 2 they lay behind.

There was a single ureter in 2 cases—in 1 of which it lay behind, in the other in front.

The renal mass was displaced downwards in 5 cases.

Other abnormalities of the body were noticed in only 2 cases, viz.:—

Recto-urethral fistula	1
Lobeless right lung	1

3. Double Ureter.

Attention may now be directed to the occurrence of a double ureter. By the term "double ureter" is meant that condition in which the ureter is double along the whole distance from kidney to bladder.

From conversations which I have had with some of my surgical colleagues at Guy's, I gather that the condition is very rarely met with at operations. The statistics quoted below show that the surgeon might expect to find it more frequently than operation records indicate hitherto. There are cases in which X-rays show a ureteral calculus which is not found at the operation. In such instances the calculus may be in the second ureter.

For many reasons I have preferred to rely upon the London Hospital records. These are so carefully kept, especially with regard to anatomical features, that I cannot help thinking that a certain distinguished member of the Anatomical Society must have kept a very watchful eye upon the post-mortem room at that hospital.

Out of 2456 cases at the London Hospital, 16 had double ureters, or roughly $\frac{2}{3}$ per cent., a figure sufficiently large to warrant the surgeon to look for it when operating on the kidney. Of these 16 cases, which do not include those cases which showed abnormal kidneys, the extraordinary feature is the large preponderance of females over males, viz. 13 females to 3 males. This is a point well worthy of consideration, not only from the operative point of view, but also from the clinical, as I think there can be little doubt that more kidneys are cut down upon for purely subjective symptoms in females than in males.

In 2 cases the ureters were double on both sides; in 7 cases they were double on the left side only, and in 7 cases on the right side only.

4. Some Points in the Surgical Anatomy of the Kidneys and Ureters.

In the list of diseases affecting the kidneys which is appended, one astonishing feature stands out quite clearly. The right kidney is affected much more frequently than the left. One reason of this is, perhaps, the relation which the large intestine bears to the kidneys. On the right side the dilated ascending colon and hepatic flexure lie in close relation to the kidney, sometimes in actual contact with its surface. On the left side the contracted descending colon is in contact with the kidney. Other relations, which need only be mentioned here, are the crossing of the right ureter by the mesentery, the more direct crossing of the iliac vessels by the right ureter than the left, and the relation of the liver to most of the pelvis of the right kidney, as compared with the relation of the pancreas to a small part of the left pelvis. Moreover, the duodenum is connected with the pelvis of the right kidney by connective tissue. I believe that all these features may conduce to a retardation of flow of urine along the right ureter, when compared with that along the left. There is absolute proof of this being the fact in six cases I have collected from my records. They are cases in which precisely the same lesions were found in both kidneys, and in which bleeding had taken place into the pelvis of both kidneys. In one of these cases clotted blood was found in both kidneys. In five of them clot was found only in the right kidney, proving, to my mind, that blood, at any rate, escapes with greater difficulty from the right kidney than from the left, and that therefore the flow of urine along the right ureter may be retarded also. Perhaps one of these cases should be rejected, as in it there was primary carcinoma of the bile-duct, which may have led to pressure upon the right renal pelvis; but the left kidney was in precisely the same pathological state as the right.

Morbid Anatomy Statistics (Renal).

	Right.	Left.	Uni-lateral.	Both.
Injury	22	19	. .	3
Calculus	102	81	5	22
(Clinical, Mr King) . .	59	41	...	...
Infarcts	52	49	...	...
Miliary tuberculosis . .	21	9	1	...
Local tuberculosis . .	11	4	...	7

Retention of blood in renal pelvis:—Right only, 5; left only, 0; bilateral, 1:

Sex.	Age.		
F	62	Growth of bile duct . .	Retention of blood in right renal pelvis.
...	...	Nodule, left kidney . .	
M	3	Multiple hæmorrhages .	
M	38	Acute or chronic nephritis .	
M	16	Cardiac	
M	$\frac{8}{12}$	Hæmorrhagic cystitis .	
		Ascending nephritis . .	
M	17	Purpura hæmorrhagica .	Retention of blood in both renal pelves.

5. The Relation of the Peritoneum to the Bladder.

Since taking up the duties of surgeon in charge of the genito-urinary department, I have been struck with two features, with regard to the relation of the peritoneum to the bladder when it is full or overfull. The first feature is clinical, and is that there is resonance over the full bladder more often than not. This means that there must be bowel in front of the full bladder, and if bowel, then general peritoneal cavity. The second feature is operative. At all operations which I have performed upon the bladder suprapubically, I have always seen the peritoneum on its anterior surface, however full it was. Obviously these features are important, especially as the books, surgical and anatomical, definitely state that the peritoneum is raised off the anterior surface of the bladder as that viscus is being filled.

I have dissected several subjects with a view to finding out what are the actual facts, and they appear to be these:—

First, an elementary point. The fundus of the empty bladder is not the fundus of the dilated bladder. To the fundus of the empty bladder the urachus is attached; as the bladder is filled, or overfilled, the urachus is pulled up, and raises a fold of peritoneum. On either side of this fold of peritoneum the general peritoneal cavity descends to a level below the upper border of the pubic ramus and body. The diagrams in the text-books of the ascent of the peritoneum with the filling of the bladder should on the one hand, if in the middle line, show the urachus, and on the other hand, if not in the middle line, should not show the peritoneum raised.

I consider that we, as anatomists, should warn the surgeon of this relation of the peritoneum to the full bladder; and at the present time I will not have suprapubic puncture performed, as I consider the risk of contamin-

ating the general peritoneal cavity too great for this operation to be justifiable. I have dissected the parts of a man who had a suprapubic puncture performed for the largest bladder I have ever seen. 102 ounces of urine were drawn off. In this case the trocar went very near to the general peritoneal cavity. In some cases of death after suprapubic puncture, uræmia has been assigned as a cause. Let us not forget the possibility of a general peritonitis. In this specimen also the general peritoneal cavity lay in front of the bladder on either side of the urachus.

6. Finally, I have dissected a specimen which indicates the importance of the branch which the renal artery sends to the suprarenal capsule. The renal pedicle had been tied, and the resulting clot in the renal artery stops short at the origin of the suprarenal branch, suggesting that the site of ligature relative to this branch should be carefully considered by the operator when the renal artery is being tied. This may be a very obvious fact which has just been demonstrated, but it affords a very interesting example of the importance of small things in anatomy.

ANOMALY OF THE INFERIOR VENA CAVA: DUPLICATION OF THE POST-RENAL SEGMENT.

By HAROLD RISCHBIETH, M.A., M.D., B.C. (Cantab.), F.R.C.S. (England), *Adelaide, South Australia.*

THE anomalous condition of the inferior vena cava here recorded was found by Professor A. Watson in a body in the Anatomical School of the University of Adelaide. The body was that of a male pauper lunatic who had died of senile decay in the Parkside Lunatic Asylum, Adelaide, at the age of 74 years.

I have to thank Professor Watson for permission to place this case on record. It seems to be of sufficient interest, in comparison with instances of somewhat similar anomalies recorded in the *Journal of Anatomy and Physiology* during the years 1911 to 1913 by Cameron, Gladstone, Johnston, and Waterston, to warrant publication.

There was a large hydatid cyst of the left lung which depressed the left dome of the diaphragm and the spleen, and appears to have caused downward displacement of the left kidney, the lower pole of which was tilted forwards, and caused chronic intestinal obstruction, of a partial kind, at the splenic flexure of the colon. The portion of colon proximal to the splenic flexure was dilated, its wall thickened, its vessels dilated, while the portion of colon distal to it was collapsed.

The conditions shown are as follows:—There are two inferior venæ cavæ posterior to the level of the renal veins; anterior to these only one. The calibre of these paired trunks seems about the same, but the left is, of the two, the lesser. With each of these venæ cavæ an external iliac and an internal iliac vein communicate—at the level of bifurcation of the common iliac artery. The internal iliac vein on each side receives the obturator vein, and, distally, does not appear to receive vessels of notably abnormal origin. But passing obliquely from the internal iliac vein of the right side to the vena cava of the left side, there is a large communicating vein, of about the calibre of the internal iliac veins of either side, which joins the left inferior vena cava above the level of bifurcation of the common iliac artery, and about 1 inch above the level of junction of the external iliac and internal iliac veins of the left side. All the main venous

trunks above described have normal relationships to arteries, *i.e.* they pass upwards internal and posterior to main arteries.

The communicating vessel that has been described as passing from the right internal iliac vein to the left inferior vena cava receives three vessels. One, the largest and to the left, is the inferior mesenteric vein.[1] The other two, of lesser calibre, and about equal in this, are lateral sacral veins.

The right inferior vena cava is joined, on its anterior aspect, about $1\frac{1}{2}$ inches below the level of its junction with the right renal vein, by the right spermatic vein, and laterally and posteriorly by three lumbar veins. The right renal vein is single, from its origin in the kidney pelvis to its junction with the "right" vena cava. The left renal vein has a double origin in the kidney pelvis. The two vessels unite to form a common left renal vein, and this, about half an inch from its origin, is joined by the left inferior vena cava. The left spermatic vein communicates with these two vessels at their junction. The common venous trunk thus formed passes obliquely upwards and to the right, immediately "tailwards" of the superior mesenteric artery, anterior to the abdominal aorta, to unite with the "right" inferior vena cava just "headwards" of the confluence of the right renal vein with this trunk. (As has been already stated, the left kidney is situated "tailwards" of the right, and this may account for the obliquity of this vessel.) The renal veins of both sides pass in front of the renal arteries. The left inferior vena cava receives, posteriorly, two lumbar veins; it also receives, at its junction with the "common" left renal vein, a vein which passes "headwards," between the left crus of the diaphragm and psoas muscle, and "headwards," a vein which appears to be musculo-phrenic. There are no transverse communications, either in front of or behind the aorta, between the right and left inferior venæ cavæ. The venous trunks joining the single inferior vena cava formed by the junction of these two (right and left) inferior venæ cavæ are in no way abnormal.

On opening the thorax the lungs were turned forwards and the thoracic venous trunks were dissected. *On the right side*, the vena azygos major arose from the ascending lumbar vein and terminated normally. *On the left side*, the inferior azygos vein arose from the vein described (marked x in the diagram) as passing into the thorax from the posterior aspect of the junction of the left common renal vein with the left inferior vena cava between psoas muscle and the left crus of the diaphragm. The left superior azygos vein was normal. No other abnormality of the venous system was noted. The arterial system in this body was apparently normal. These conditions are broadly shown in the accompanying photograph (fig. 1),

[1] Thus the superior hæmorrhoidal vein communicates with the general venous system and not with the portal system.

and an attempt has been made to represent them more clearly and fully in the diagram (fig. 2).

Fig. 1.

The anomaly may be explained as an abnormal persistence of the posterior cardinal vein on the left side as far "headwards" as the left renal vein. I do not propose to discuss the significance or origin of the condition

shown, as the whole of this subject has been recently discussed in the *Journal of Anatomy and Physiology*. It suffices, therefore, to record facts.

It may be of interest, however, to compare this case with some of the

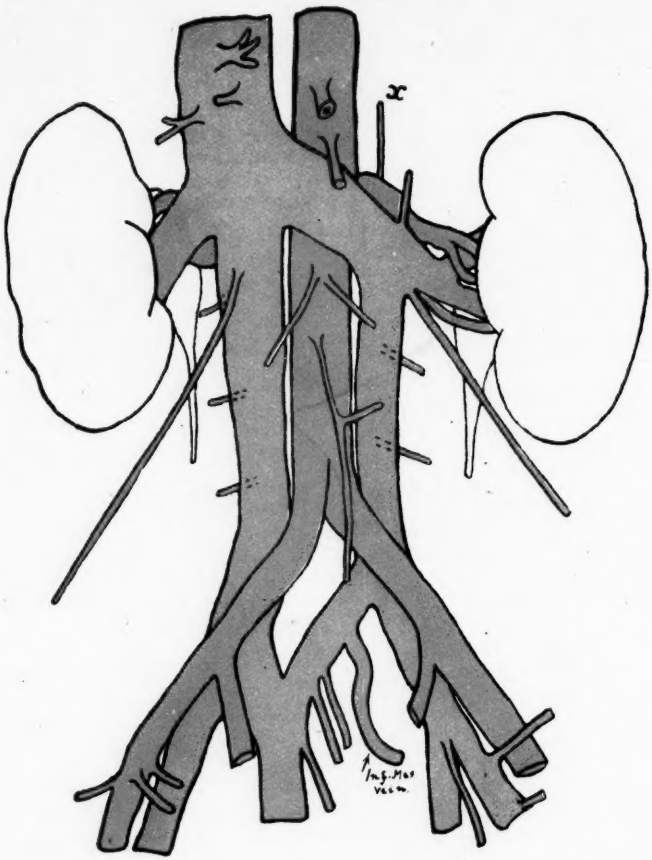

FIG. 2.

instances of somewhat similar anomalies of the inferior vena cava that have been recorded. In the *Journal of Anatomy and Physiology*, vol. v., 1871, p. 227, there is an account quoted from the *Nederlandsch Archief voor Genees. en Natuurkunde*, vol. v., of an anomaly of the inferior vena cava which seems to show some resemblances to the present case. But the

description appears to me to be indistinct; at least I cannot clearly perceive what the conditions were from it. Mr Waring (*Journal of Anatomy and Physiology*, vol. xxviii., 1894, p. 46) states: "Many examples of double inferior vena cava have been recorded by Gruber, Kadzi, Nicolai, Petsche, Kollmann, Walter, and Walsham." He then proceeds to describe a case of left inferior vena cava without transposition of viscera. To this one need only refer in passing. In the same volume of this journal, p. 376, Professor Bertram Windle, in a "Report on Recent Teratological Literature," refers to Kollmann's account of a number of abnormalities in connexion with the inferior vena cava. Professor A. Keith, in a paper upon "The Frequent Occurrence of a Divided Inferior Vena Cava in the Genus Hylobates (Gibbon)," which is published, in abstract, in *The Proceedings of the Anatomical Society of Great Britain and Ireland*, November 1895 (*Journal of Anatomy and Physiology*, vol. xxx., 1896, Proceedings, ii.), refers to six specimens that he had dissected, and in four of which the inferior vena cava was divided in the region posterior to the kidneys. (In two of these the left renal vein passed in front of the abdominal aorta to join the right renal vein, as in our case. In the other two, the left renal vein passed behind the aorta.) In this paper Professor Keith referred to the fact that Kollmann had found about thirty cases of this arrangement of veins recorded as having occurred in man; but he, Professor Keith, thought it was probably much more frequent than this small number suggested, probably as frequent as 1 in 150 bodies.[1] In this paper it is stated, upon the authority of Hochstetter, that a divided inferior vena cava occurs in the Ornithorhynchus and Echidna, in dolphins, seals, hedgehog, cat, and rabbit. In some of these animals Professor Keith had verified the statement, but he had not found the condition in fifty Catarrhine monkeys dissected.

"Amongst Gibbons, divided inferior vena cava occurs most frequently in the female; this is probably true also of the human race. The usual persistence of the right cardinal vein as the entire vena cava may be connected with the lower position of the right kidney; at any rate, in the case of a left inferior vena cava, and often in the cases of divided inferior venæ cavæ, the left kidney was lower than the right."[2]

At the same meeting of the Anatomical Society, Mr Parsons showed a

[1] Professor Watson states that in 496 bodies dissected in the Anatomical School of the University of Adelaide, the case here described was the only instance of it that occurred. But in another body in this number the superior vena cava was on the left side.

[2] This is of interest in connexion with the present case; for here the left kidney is lower than the right. There is, however, another possible explanation here. There is a large hydatid cyst occupying the lower lobe of the left lung. This pushes down the left dome of the diaphragm, and, by pressure upon the spleen, may be the cause of the low position of the left kidney, the lower pole of which is also displaced forwards.

drawing of a double inferior vena cava found in the St Thomas's Hospital dissecting room, in a male subject. At this meeting Mr Black also referred to two cases in man. Professor Dwight (*Journal of Anatomy and Physiology*, vol. xxxv., 1901, p. 12), states: "A not uncommon anomaly is the persistence of what is commonly called the lower part of each cardinal as high or higher than the renal veins"; but he is dealing with "Absence of the Inferior Vena Cava below the Diaphragm," and the condition that he shows in the plate is not the same as in our case.

In the same volume of this *Journal*, p. 123, are accounts of four cases of anomalous inferior vena cava from the dissecting room of the University of Cambridge. Two of these appear to have been very like the case here described.

In the *Journal of Anatomy and Physiology*, vol. xlv., 1911, p. 416, is an account by Dr John Cameron of an instance of persistence of the left posterior cardinal vein which presents some slight resemblance to our case, but also considerable differences. Gladstone, in the same *Journal*, vol. xlvi., 1912, p. 220, records a case of left inferior vena cava. This seems to represent a different developmental anomaly, but comparison with the present case may be of interest.

In the *Journal of Anatomy and Physiology*, vol. xlvii., 1913, p. 235, Johnston describes an anomaly of the inferior vena cava with which it also seems of interest to compare our case; while in the same volume of this *Journal*, p. 433, Waterston describes an instance of "duplication of the post-renal segment of the vena cava inferior" which shows a condition almost identical with it—yet not quite.

References to a considerable number of further publications upon the subject of anomalies of the inferior vena cava are given by these authors in their papers; but I cannot obtain these in South Australia. Perusal of the papers above referred to seems, however, to justify the inference that duplication of the post-renal segment of the inferior vena cava is a not very uncommon anomaly. There appears, however, to be some difference of opinion upon the question whether the paired or the unpaired anomalies of the vena cava inferior are the more frequent. For instance, Waterston, if I understand him aright, thinks the latter are the more frequent; but most of the other authorities quoted appear to hold a contrary opinion. The purpose of the present paper is not to determine this point, but to record the facts of our case, which, for purposes of comparison or contrast, seems to be of sufficient interest to warrant publication.

A COMMUNICATION AS TO THE CAUSATION OF LARGE VASCULAR GROOVES FOUND ON THE INNER ASPECT OF THE OS PARIETALE.

By Bernard Coen, M.B., *Demonstrator of Anatomy, University of Sydney.*

The grooves I wish to draw attention to are to be found close to the grooves formed by the middle meningeal vessels; in fact, they are sometimes the only grooves to be seen. They are not of frequent occurrence and they differ markedly in character from the ordinary meningeal grooves.

Many writers have noted that grooves differing in character from the ordinary meningeal grooves are to be found close to the coronal suture, but have not attributed them to causes other than the meningeal vessels.

Professor Elliot Smith records the case of a man falling as the result of a cerebral hæmorrhage and fracturing the skull from one temporal region to the other along large grooves which were in position just posterior to the coronal suture. The grooves in the case he mentioned were very deep, and extended down to the inner aspect of the outer table of the skull (1).

Poirier and Charpy have apparently described these grooves, and speak of them quite explicitly as being due to the meningeal vessels (2).

In a recent paper of Dr Wood Jones these grooves are attributed to meningeal vessels (3).

In one writer only, Oscar Schultze, have I been able to find an account testifying to the fact that diploic veins have come to the surface of the meninges. The writer, however, apparently describes small veins near the vertex of the parietal bones (4).

With the evidence before me, I must express the view that though some of the larger grooves are meningeal in origin, others are not due to the meningeal vessels, but have been caused by the diploic venous tissue eroding the inner table of the skull and leaving deep gutter-like grooves as the result.

I recently examined, in the dissecting-room, the skull of a Chinaman. The certificated cause of death was "senile decay." The skull showed a large deep vascular groove just posterior to the coronal suture on the left side (fig. 1, *a*). A few millimetres posterior to this groove was another,

much shallower, groove which ran parallel to it in the lower part of its course, but which diverged from it as it was traced up towards the vertex. On the inner aspect of the right parietal bone of the same skull enlarged diploic vessels could be plainly detected through the inner table; they appeared as bluish linear stains (fig. 1, *b, c, d*). This is, I think, a somewhat unusual condition, and it was this chance finding of the venous diploic tissue visible through the inner table which suggested that the large deep

FIG. 1.—Photograph of cerebral surface of calvaria of a Chinaman (senile) showing:—

a, a, a, large vascular groove of diploic venous origin. Skirting the posterior margin of this groove may be observed a small and shallow "meningeal groove" proper; *b, c, d*, dark linear stains over right parietal bone due to underlying diploic veins. (During subsequent treatment the specimen was accidentally broken along the line *c*. The inner table was carefully removed along the line of the linear stain *d*.)

groove on the left parietal was of diploic origin. The observation of these facts, and the suggestion they give rise to, may not be sufficient to bear out the contention I have advanced. There are, however, other reasons which may be obtained from (1) a study of the characters of the large groove compared with those of the groove lying posterior to it, which latter is admittedly due to a meningeal vessel; (2) a study of the characters of the grooves that the diploic venous tissue gives rise to on the inner aspect

of the outer table of the skull, where this forms the outer wall of a normal diploic canal.

For purposes of further investigation, I firstly removed from the inner aspect of the right parietal bone the inner table, where it overlaid some of the stains, and took away the venous tissue (fig. 2, *d*). Secondly, I filed away the outer table of both the left and the right parietal bones. (Unfortunately, whilst doing this, the skull broke, hence the disparity of

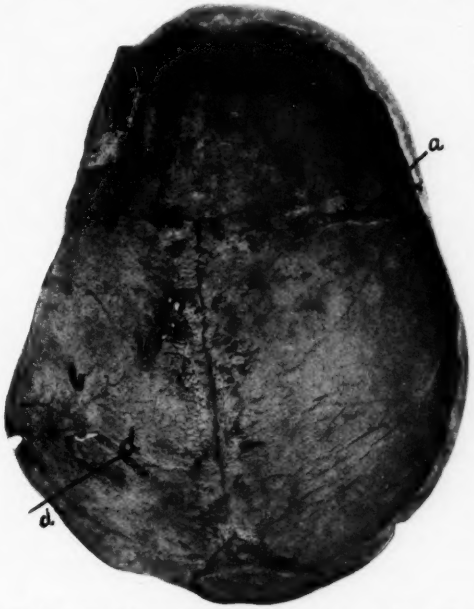

FIG. 2.—Photograph of the same aspect of the same specimen after removal of the thin inner table along the line of *d* in fig. 1. The result is a groove of very similar character to *a*.

b, *b*, these linear stains are no longer so evident as in fig. 1, because the diploic venous tissue has been removed by dissection from the outer aspect.

the photographs.) On the right side, as I approached the diploë, dark stains appeared in places, and on proceeding further these stains were found to overlie venous channels in the diploë (fig. 3, *f*, *f*). I next removed the venous tissue from these channels and found that the inner table on which it rested was at some points remarkably thin, and that it easily transmitted light. After filing away the outer table of the left parietal there appeared to be no marked development of the diploic channels. However, opposite the large deep channel posterior to the coronal suture a

dark linear stain appeared similar to the staining noticed on reaching the diploic channels on the right side (fig. 3, *e*, *e*).

In connexion with the two questions above referred to, I note that (1) the characters of the large groove under consideration, as well as of some others I have examined, were as follows:—The groove was deep and rugged, its edges were sharp and overhanging. This appearance is in accordance with what would be expected to follow if the most prominent

FIG. 3.—Photograph of outer aspect of the same specimen after the outer table of the skull has been removed by filing.

e, *e* shows a linear stain corresponding to the groove *a* of figs. 1 and 2; *f*, *f*, *f* shows the diploic channels of the right parietal bone corresponding to the linear stains *b* and *d* in figs. 1 and 2. Note the comparative absence of similar channels over the left parietal apart from groove *a* in figs. 1 and 2 (*e* in fig. 3).

part of an underlying vein had absorbed the inner table by inducing a pressure atrophy. I believe that such an atrophy may and does happen, despite the contrary tendency on the part of the inner table, which may grow over so as to enclose the meningeal vessels, a condition frequently witnessed in adult development, especially near the antero-inferior angle of the parietal bones. But the ordinary meningeal grooves have their edges smooth and everted, and the grooves slope gradually down to their

greatest depth. Of such a character was the posterior of the two grooves in the skull under question.

In one markedly senile skull from our collection, with edentulous and atrophied maxillary alveolar arches, the calvaria is also remarkably atrophied, and shows one of these same large vascular grooves lying just posterior to the coronal suture. The edges of the groove are in some places only about 2 mm. apart, whereas the lateral walls of the groove are 5 to 6 mm. apart. If we suppose the subject to whom this skull belonged had suffered from any venous engorgement during his lifetime, we have two very potent factors at work which certainly would tend to bring a diploic vein to the surface of the meninges, and the vascular groove so formed would undoubtedly be of diploic origin.

(2) On the inner aspect of the right parietal bone, after removing the inner table over the linear stains and taking away the venous tissue underlying them, the character of the grooves left on the inner aspect of the outer table was in every way comparable with the large groove on the left side. I have mentioned that the intact inner table overlying some of the venous diploic channels was extremely thin. If this subject had suffered from either venous engorgement or his skull had shown any degree of general atrophy, there can be no doubt that on the right side we would have had marked open vascular channels appearing on the inner aspect of the right parietal bone.

In some cases it is quite possible that ordinary meningeal vessels may come to lie in such grooves. This would occur if the meningeal vessels chanced to be opposite the eroding diploic veins, and I have specimens showing this condition, there being a very thin lamina of bone intervening. This appears to be borne out, too, in those cases in which one edge of these large grooves overhangs the groove and the other edge is smooth and everted.

Summary of Conclusions.

1. That some of the large gutter-like grooves found in the inner aspect of the skull are due to diploic venous tissue which has come to the surface by the erosion of the inner table of the skull.

2. That it is possible that when there is only one large gutter-like groove present the meningeal and diploic vessels may be contained in the same groove.

3. That the factors at work producing these grooves are:—

   (*a*) Large diploic vessels to commence with.

   (*b*) Some degree of venous engorgement.

   (*c*) An atrophying skull consequent on advancing age.

REFERENCES.

(1) Professor Elliot Smith, *Review of Neurology and Psychiatry*, March 1905.

(2) Poirier and Charpy, tome ii., part ii., p. 930.

(3) Frederic Wood Jones, D.Sc., *Journal of Anatomy and Physiology*, vol. xlvi., third part, April 1912, p. 228.

(4) Oskar Schultze, *Zeitschrift für Morphologie und Anthropologie*, Band i., p. 451.

THE INTERRELATIONSHIP OF SOME TRUNK MEASUREMENTS AND THEIR RELATION TO STATURE.

By RUPERT M. DOWNES, M.D., M.S. (Melb.). (*From the Anatomy Department, Melbourne University.*)

ANTHROPOLOGICAL literature contains many works concerning the length of the limbs and trunk, the transverse diameters of the trunk at the shoulder and in the region of the pelvic girdle, and various correlations arising from these measurements as embodied in the canons of Fritsch and others.

As the standards of the different diameters of the trunk are so much a matter of individual selection, I have undertaken the observations here set down on the transverse diameters in the pelvic region with the intention of deciding which one is the most suitable as a standard measurement, and to compare the ratios of the trunk diameters to one another and to the body height.

I entered on this line of research at the suggestion of Professor Berry that it would be of value to determine the ratio between the interspinous and vertical trunk diameters; he also permitted me the use of two tables of such ratios obtained from measurements he had made himself and that he had prepared from Addison's paper on abdominal topography (1).

He also hoped that some conclusions might be drawn from these measurements as to the value, for clinical purposes, of sections made of trunks of varying stature at fixed levels; for if the vertical trunk diameter were found to be at all constant, the value of such sectional methods would be obvious.

NATURE OF THE INVESTIGATION.

The following diameters were determined:—

1. Total body height.
2. Vertical trunk diameter.
3. Interspinous diameter.
4. Intercristal diameter.
5. Intertrochanteric diameter.
6. Diameter from midline to anterior superior iliac spine.

The relative proportions of these diameters were expressed by the following indices:—

1. Vertical trunk-body height index.
2. Interspinous-vertical trunk index.
3. Interspinous-body height index.
4. Intercristal-vertical trunk index.
5. Intercristal-body height index.
6. Intertrochanteric-body height index.
7. Interspinous-intercristal index.

Number and Nature of the Material.—The number of cases examined was 201; of these 51 were adult women, 50 men, 47 male and 53 female children. The ages of these ranged from six months to ninety years, all the children being under fourteen years. Of the adults, 18 were formalin-hardened subjects from the dissecting-room; the remainder and all the children were live subjects.

Technique.—In all cases the subjects were in the supine position and the measurements were recorded with Martin's anthropometer. The vertical trunk diameter was determined by marking the level of the cranial margin of the symphysis ossium pubis on the skin, placing one limb of the instrument so as to press firmly on the cranial margin of the sternum, then moving the other limb on to the pencil mark.

For the determination of the interspinous diameter the most medial extremities of the anterior superior spines of the ilium were employed as the limits of this diameter, and not the most prominent points of these spines, as is the more usual custom; their positions were then marked on the skin. This was found to be simpler and more accurate than the commoner method of placing the calliper directly on the prominences in the soft tissues formed by these bony points. At the same time the diameter from either spine to the midline of the trunk was measured in the line of the previous diameter. Maximum pressure was used in the determination of the intercristal and intertrochanteric diameters to eliminate as far as possible variations due to the intervening soft tissues; to measure the latter diameter the inferior extremities were approximated and the thighs and legs fully extended.

It has been frequently remarked that body height is greater in the supine than the erect position, so that the supine position was used in determining this diameter as less liable to variation and because it is applicable to cadavera. Unless otherwise stated, the measures are given in centimetres.

Vertical Trunk Diameter.—For the estimation of this diameter several different methods have been employed, one of the most common perhaps

being the measurement from the acromion process to the sitting level. As examples of others we have the distance from the spine of the seventh cervical vertebra or the manubrium sterni to the sitting level, and Teumin (2) has recorded seven different methods in all.

If any method be employed which involves the determination of the sitting level, there is the source of error in the measurements due to varying amounts of fatty tissue overlying the tubera ischiadica. In addition great variations in the length of this diameter are produced by differences in the ventro-dorsal curvatures of the spinal column, by scoliosis, and by compression of the intervertebral fibro-cartilages. The alteration of this measurement produced in any individual by sitting rigidly erect from that found when he sits at ease is quite marked; it is produced by change of spinal curvature and also by allowing different portions of the tubera ischiadica to support the trunk with corresponding change in the height of the trunk. Moreover, this method is not applicable to cadavera. On the other hand, if instead of employing the sitting posture the subject be placed in the supine position, these sources of error are eliminated, but the sitting level or tubera ischiadici can no longer be used because of the practical difficulties of determining their positions.

In my opinion, then, the vertical trunk diameter is best determined with the body supine, and in this position the most simple method and the one least open to error is to record the distance between the cranial margins of the manubrium sterni and symphysis ossium pubis respectively.

Teumin, in an important paper on physical dimensions, comments on this question and also favours the manubrio-pubic diameter; she found that this method gives the greatest variations between maximum and minimum trunk lengths. She also found that the manubrium lies caudal to the spine of the seventh cervical vertebra by a true mean of 4·7 cm., obtained from her figures, and in 64 per cent. of cases is cranial to the acromion. She, however, employed the erect attitude in her series of 100 women, using Martin's anthropometer, and including some as young as eighteen years of age. The true mean of the vertical trunk diameter obtained from her figures is 48·2 cm., with variations from 41 to 62 cm., while she quotes the averages of this diameter obtained by other writers who employed this method, and which are tabulated below.

The true mean for the combined cases of Berry and Addison is 52·9 cm. in 49 males and 50 cm. in 24 females, with variation from 47 to 58 cm. in the former and from 46 to 54 cm. in the latter. All were over the age of twenty-one years. My own cases over the age of twenty-one give a true mean in 42 men of 51·12 cm., with a standard deviation of 2·64 cm.; and in 38 women of 48·46 cm., with a standard deviation of 2·93 cm.

The conclusions drawn from my figures is that the range of variation in the vertical trunk diameters of different individuals is not great, as the standard deviations mentioned above are so small. The figures of the other writers now quoted, however, show a considerable variation, though the standard deviation in their cases is not stated.

	No. of Cases.	Males.	Females.
Teumin	(100)	...	48·2 cm.
Jakowenko	(?)	49·46 cm.	...
Downes	(81)	51·12 ,,	48·46 ,,
Standard deviation from the true mean		2·64 ,,	2·93 ,,
Gittschenko	(?)	52·35 ,,	...
Berry and Addison	(73)	52·9 ,,	50 ,,
Dibold	(?)	56·66 ,,	...

It is apparent, too, that this diameter in men is appreciably greater than in women.

Interspinous Diameter.—For this diameter I have recorded the distance between the most medial points of the anterior superior iliac spines instead of their most prominent points, which is the usual method, because I have found that there is a variability in the position of the latter points and because of the difficulty of determining these points with accuracy. In consequence of this my measurements are distinctly lower than those of other observers.

It has been stated in some anatomical and obstetrical text-books that this diameter is greater in females than males, but the bulk of evidence is against this view.

According to Cunningham (3), the female diameter is greater, while Waldeyer (4) states that they are equal in the two sexes. The remaining

	Males.	Females.
Downes	22·62 cm.	21·98 cm.
Standard deviation from the true mean	1·21 ,,	1·94 ,,
Verneau (5)	23·1 ,,	22·2 ,,
Quain (6)	24·1 ,,	23·5 ,,
Cunningham	24 ,,	25 ,,
Berry and Addison	24·27 ,,	23·58 ,,
Teumin	...	24·42 ,,
Waldeyer	26 ,,	26 ,,

writers I quote show a larger male diameter. My figures, though lower than others, as mentioned previously, show the male diameter of 22·62 cm. to be greater than the female diameter of 21·98 cm.

Intercristal Diameter.—All writers except Waldeyer and Weissenberg (7) are agreed that this diameter is greater in the male, and my results bear this out. In contrast to the last diameter I find, however, that the standard deviation of 1·8 cm. in females is greater than that of males, which is 1·33 cm.

	Males.	Females.
Waldeyer	26 cm.	29 cm.
Weissenberg	27·7 ,,	28·1 ,,
Verneau	27·9 ,,	26·6 ,,
Cunningham	28·2 ,,	27·3 ,,
Quain	11¼ in.	11 in.
	28·58 cm.	27·94 cm.
Downes	29·19 ,,	28·11 ,,
Standard deviation from the true mean	1·33 ,,	1 8 ,,
Addison	29·48 ,,	28·55 ,,

This diameter appears to be most suitable for employment as a standard of transverse trunk diameter, for the following reason :—

As mentioned previously, the most prominent points of the anterior superior iliac spines are variable in position and difficult to determine. Even if we fix on their most medial margins there is still some difficulty in determining these points with exactness, while this trouble is absent if we employ the intercristal diameter. Again, this diameter can be determined more rapidly and with less exposure, which is of some importance in the case of women, and it certainly is less open to error.

Intertrochanteric Diameter.—According to Merkel, from measurements made on the skeleton this diameter is greater in the female, while Waldeyer states that it is equal in the sexes. My results show that what little difference there is, is on the side of the greater male diameter.

	Males.	Females.
Waldeyer	31·5 cm.	31·5 cm.
Downes	32·1 ,,	31·87 ,,
Standard deviation from the true mean	1·36 ,,	1·59 ,,
Merkel (8)	32·5 ,,	34 ,,
Stratz (9)	...	33·5 ,,

Asymmetry.—The generally accepted idea that few individuals are bilaterally symmetrical has led me to test this characteristic at the interspinous level. To make allowance for observational errors, in no case was

asymmetry considered to be present unless a variation of ·5 cm. or over was found on either side.

This margin is rather wide, especially in young children, but I found that even among them asymmetry is nearly as common as in adults, using this arbitrary minimum.

Of 201 cases examined, 104 were asymmetrical, in 60 cases the greater diameter being on the left side and in 44 on the right side. The increase in the right diameter is more marked in adults, and is due, no doubt, to some scoliosis produced by habitual usage of the right arm, which is more apparent with increase in age. Asymmetry, moreover, is most present in adult females, and also more so in female than male children.

Vertical Trunk-Body Height Index.—An index to express the ratio of these diameters is obtained by the following formula:

$$\text{Index} = \frac{\text{vertical trunk diameter} \times 100}{\text{body height}}.$$

This ratio is of considerable interest, and Addison has pointed out its remarkable constancy. Reid (10) apparently does not agree with this, for from his observations on University students he states that increased stature seems to be chiefly due to greater trunk length. My results confirm Addison's observation and further emphasise the point, which is not new, that the vertical trunk diameter in the female is relatively greater than in the male, though, as I have shown before, it is less actually. Pittard (11), too, after measurements of over 1200 Hungarians, states that the female trunk is relatively longer than the male; and Weissenberg emphasises the female superiority in this index, drawing attention to the fact that women when sitting frequently appear to be taller than their male companions, while on standing they are obviously shorter. I think that this observation is misleading, and is due to the fact that women usually sit more erectly than men—largely owing to artificial support by corsets,—and that in the female the development of adipose tissue in the buttocks is so frequently greater than in the male. For my results show that the sexual variation in this index, though in favour of the female, is very small, whilst there is a direct contradiction in the previously mentioned figures of Berry and Addison and myself, which show that the absolute vertical trunk diameter is greater in men.

Weissenberg, though employing the acromion to sitting level diameter to indicate trunk height, found—as I have done—that the same small relative sexual difference is present in children. The true mean of the index which I have extracted from Teumin's indices is 30·3, with a range of variation from 21 to 40. Below are tabulated the averages of indices quoted by

her. The true mean of the index which I obtained from Addison's measurements is rather higher in each sex than mine, which show so small a variation in the index from each group and so little standard deviation.

	Males.	Females.	Male Children.	Female Children.
Downes	30	30·57	29·89	30·53
Standard deviation from the true mean	1·15	1·54	1·66	1·58
Teumin	...	30·3	...	...
Jakowenko	30·58	...	...	...
Gittschenko	30·77	...	...	...
Wischegrord	31·19	...	...	...
Addison	31·73	32·42	...	...
Eicholz	31·9	...	...	...
Dibold	33·3	...	...	...

Proportion of Trunk and Leg Lengths.—Though I have made no observations on this subject yet it is instructive to quote Teumin, who showed that in women there was a great constancy in the relative height of the manubrium from the ground—about 82 per cent. of the body height. As the relative trunk length is also constant, it follows that the relative leg length in women is constant too. Le Damany (12) found in the new born that this ratio was not different in the sexes.

Interspinous-Vertical Trunk Index.—I have found no record in the literature of this index having been considered previously, and have only the indices prepared from Berry and Addison's figures to compare with my own. These show, as do also mine, that this index is considerably greater in the female, though Berry and Addison's figures are higher than the present writer's owing to differences in the method of determination of the interspinous diameter.

In children, however, this sexual relation is reversed, the male index being greater. In all classes the standard deviation from the mean is high, so that this index is not a suitable symbol of trunk proportions.

	Males.	Females.	Male Children.	Female Children.
Downes	43·56	44·67	44·23	42·06
Standard deviation from the true mean	3·48	4·14	3·14	3·75
Berry and Addison	45·75	46·92	...	...

Note.—In this index table and in those that follow I have included 8 males and 13 females between the ages of sixteen and twenty-one.

Though the elimination of the indices obtained from them raises the true mean, it does so only to an inappreciable extent.

Interspinous-Body Height Index.—The true mean of this ratio shows the same comparative results in accordance with sex and age as in the last index. The index for women is greater than for men, while male children have a higher index than female.

	Males.	Females.	Male Children.	Female Children.
Downes	12·97	13·68	13·22	12·83
Standard deviation from the true mean	3·48	4·14	3·14	3·75
Berry and Addison	14·47	15·12	...	...

Intercristal-Vertical Trunk Index.—The figures show again the same sexual and age relations as the interspinous indices. The standard deviation from the mean in this group is greater in women; this is not found in the other indices.

	Males.	Females.	Male Children.	Female Children.
Downes	56·36	57·88	55·43	53·19
Standard deviation from the true mean	3·82	3·33	3·39	3·8
Addison	55·83	58·27	...	...

Intercristal-Body Height Index. — The relations of the four groups are similar to those of the preceding indices. Addison's true mean becomes considerably higher than mine, and is 16·99 in males and 10·48 in females.

Browein (13) obtained an index of 16 in men and 18·3 in women, while Weissenberg makes the figures 16·8 and 18·3 respectively.

	Males.	Females.	Male Children.	Female Children.
Browein	16	18·3	...	...
Weissenberg	16·8	18·3	...	...
Downes	16·87	17·7	16·42	16·23
Standard deviation from the true mean	1·03	·9	·69	·86
Addison	16·99	18·48	...	...

The measurements and indices so far considered show some remarkable results.

Primarily it is apparent that the actual transverse diameters of the false pelvis, as measured between the anterior superior iliac spines and between the iliac crests, are greater in males than in females. This is contrary to the common loose and unqualified statement that the female pelvis is broader than the male, and is in agreement with the results of the majority of writers already quoted.

A review of the indices, however, shows a very different state of affairs, for now we find that each of these diameters relatively to trunk and body height is greater in women than in men. In other words, the adult female actually has a narrower false pelvis than the male, but relatively it is broader.

In children, however, the relation of the sexes is reversed, for in all four groups the male child has a greater index—that is, a wider pelvis relatively —than the female. It necessarily follows too that the index is greater in women than in the female children in the four groups; the interspinous indices, however, are greater in male children than in men, while the position is reversed for the intercristal indices.

I have already stated that I consider the intercristal diameter as the best for standard transverse pelvic measurements, and the manubrio-pubic diameter as the most suitable to indicate vertical trunk height. It follows from this that the intercristal manubrio-pubic index is most convenient and accurate as a symbol of the form of the trunk.

Intertrochanteric-Body Height Index.—As the true pelvis is said to be both actually and relatively greater in the female, this index is considerably greater by nearly 7½ per cent. in women. In children also the female index, unlike those in the other groups, is slightly greater than in the male. This denotes a marked increase relatively in this diameter in the female after puberty.

In contrast to this the interspinous and intercristal diameters have been seen to be greater relatively in the male before puberty, but in the female in adult life, so that lateral development of the pelvis seems to be more marked in women after puberty. My results are :—

	Males.	Females.	Male Children.	Female Children.
Intertrochanteric body-height index .	18·59	20·09	17·59	17·92
Standard deviation from the true mean	·85	·95	·75	·93

Interspinous-Intercristal Index. — This index shows a very slight sexual difference in adults, women having a slight superiority with an

index of 77·25 over the male index of 77. In women the standard deviation from the mean rises to 5, while in men it is 3·97. Teumin has calculated this index, of which the true mean is 88 in women, with a range of variation from 67 to 96, but this can be explained by the different points adopted for the limits of the interspinous diameter. If we can take this small sexual difference to mean anything, we must conclude that the pelvic alæ are less concave in the female, giving a comparative increase in the lateral capacity of the false pelvis.

Conclusions.

1. The vertical diameter of the trunk is most readily and accurately estimated by measurement from the cranial margin of the manubrium sterni to the cranial margin of the symphysis ossium pubis.

2. The vertical trunk diameter, though actually smaller in women, is greater relatively to the body height. This comparative difference is more marked in children. The relation of vertical trunk to total body height, as previously noted by Addison, is almost a constant, and is about 30 per cent. of the latter.

3. The interspinous and intercristal diameters are greater in males; relatively to vertical trunk diameter and body height, they are greater in the female. Amongst children the male has a greater index than the female. The indices are higher in adults than in the corresponding classes of children, except that the interspinous indices are greater in male children than male adults.

4. The intertrochanteric diameter is greater in the male, but relatively to body height it is considerably greater in the female. This relative superiority is also present in children.

5. The pelvic alæ have a smaller concavity in the female.

6. Asymmetry of a recognisable degree is present in over 50 per cent. of all subjects. It is more frequent in females, especially adults.

7. The indices showing the relation of transverse to vertical trunk diameters are greater in adults than children.

8. As a rule, the standard deviation shows that there is a greater range of variation in the female sex.

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[Tables.

Male Children.

Age.	Interspinous diameter.	Intercristal diameter.	Intertrochant. diameter.	Vertical trunk diameter.	Height.	Diff. in sides.	Greater side.	Index No.					
								1.	2.	3.	4.	5.	6.
8	15	20	20·5	33	121	...	...	27	45	12·4	61	16·5	17
6½	16	19	19·5	36·5	116	1·2	R	31	44	13·8	52	16·4	17
3¾	14·5	17	18	29·5	97	...	...	30	49	15	58	17·4	18·5
4	13	16	16·5	26·5	93	...	...	29	49	14	60	17·2	17·5
4½	12	16	17·5	30·5	100	...	...	31	38	12	53	16	17·5
13	17	22	24	41	141	1·1	L	29	41	12·1	54	15·6	17
9	16·5	20	21	38	129	8	R	29	43	12·8	53	15·5	17
4	12·5	17	17	30·5	97	...	...	31	40	12·9	56	17·4	17·5
6	12·5	16·5	18	32·5	106	...	...	31	38	11·8	56	15·6	17
1¾	10·5	13	14	26	80	...	...	32	40	13·1	50	16·3	17·5
7	15·5	19	20	32·5	114	·8	L	29	48	13·6	58	16·7	17·5
2½	11·5	14	16	24·5	86	...	...	29	43	13·4	57	16·3	18·5
5	12·5	17	19	32	108	·8	L	30	39	11·6	53	15·7	17·5
2	11	12·5	14	25·5	76	·9	L	34	43	14·5	49	16·5	18 5
5	13·5	17·5	18·5	30·5	105	·9	L	29	44	12·8	57	16·7	17·5
12	18·5	22·5	24 5	42	143	·9	R	29	43	12·9	54	15·7	17
1 8/12	11·5	13·5	14·5	26	80	...	..	33	44	14·4	52	16·9	18
6	14	17·5	19·5	29·5	103	...	...	29	47	13·6	59	17	19
9	15·5	20	21	37	120	...	...	31	42	12·9	54	16·7	17·5
6	14	18 5	20·5	32·5	111	...	...	29	43	12·6	57	16·7	18·5
13	17	22	23·5	38·5	132	...	...	29	44	12·9	57	16·7	18
13	17·5	22	23	39·5	129	·6	R	31	44	13·6	56	17·1	18
3	13	16·5	17·5	27·5	93	1·5	L	30	47	14	60	17·7	19
10	16	19·5	21	38·5	121	...	...	32	42	13 2	51	16 1	17·5
9	16	21	22·5	40·5	133	·8	L	30	40	12	52	15·8	17
9	15·5	19·5.	21·5	33·5	133	...	...	25	46	11·6	58	14·7	16
14	21	26	29·5	43	160	...	...	27	49	13·1	60	16·2	18·5
8	15·5	19	20	32·5	114	...	...	29	48	13·6	58	16·7	17·5
3	13·5	16·5	17·5	28·5	93	·5	R	31	47	14·5	58	17·7	17·5
8	15·5	20	20·5	33·5	128	...	...	26	46	12·1	60	15·6	16
11	16·5	21·5	24	41	137	·7	R	30	40	12	52	15·7	17·5
3½	12	13·5	14	24·5	79	...	...	31	49	15·2	55	17·1	17·5
3	13·5	16	16·5	25·5	89	1·3	L	29	53	15·2	63	18	18·5
7	14·5	17·5	19·5	34·5	111	...	...	31	42	13·1	51	15·8	17·5
11	17	21·5	22·5	38	135	1·1	R	28	45	12·6	57	15·9	16·5
5	13 5	16·5	16·5	30·5	102	...	...	30	44	12·2	54	16·2	16
5½	15	19	19	32·5	113	...	...	29	46	12·2	58	16·8	17
12	18·5	22	23	42·5	131	·5	L	32	43	14·1	52	16·8	17·5
12	18·5	23	25·5	42·5	141	...	...	30	43	13·1	54	16·3	18
1 1/12	11	12·5	15	25·5	81	1·9	L	31	43	13·6	49	15·4	18·5
3	11·5	13·5	15	25·5	83	·5	L	31	45	13·8	53	16·3	18
3½	13·5	16·5	18	30	97	·8	L	31	45	13·9	55	17	18·5
11	18·5	23	24	41	141	·5	R	29	44	13·1	56	16·3	17
12	18·5	21·5	23	41·5	133	1·9	R	31	44	13·9	52	16·1	17·5
13	17·5	23·5	24	38	137	1	R	28	46	12·8	62	17·1	17 5
7	16·5	19	21·5	34·5	113	...	...	31	48	14·6	55	16·8	19
2	11·5	14·5	14·5	27	87	1·1	L	31	43	14	54	16·7	16·5

FEMALE CHILDREN.

Age.	Interspinous diameter.	Intercristal diameter.	Intertrochant. diameter.	Vertical trunk diameter.	Height.	Diff. in sides.	Greater side.	Index No.					
								1.	2.	3.	4.	5.	6.
13	17·5	20·5	26	44·5	140	...	...	32	39	12·5	46	14·6	18·5
4	14	16·5	18	33	101	·9	R	33	42	13·9	50	16·3	18
3½	12·5	14·5	16·5	26	89	...	...	29	48	14	56	16·3	18·5
1½	10·5	13	14·5	25	78	...	...	32	42	13·5	52	16·7	18·5
8 1/12	10	13	14 5	25	74	...	...	34	40	13·5	52	17·6	19·5
12	16·5	22	25·5	42·5	145	...	...	29	38	11·4	52	15·2	17·5
12	18	22	23	40·5	136	·8	L	30	44	13·2	54	16·2	17
10	17·5	21·5	23	42	131	...	...	32	42	13·4	51	16·4	17·5
10	15	21	23	43·5	136	1·	R	32	34	11	48	15·4	17
9	17·5	22	23	42	138	...	...	30	42	12·7	52	15·9	17
4	14	16·5	17	27·5	95	...	...	29	51	14·7	60	17·4	18
8	15	21·5	23·5	39·5	133	·8	R	30	38	11·3	54	16·2	17·5
13	19·5	26	29	44·5	141	...	...	32	44	13·8	58	18·4	21
1½	11·5	13	14	25	75	...	...	33	46	15·3	52	17·3	18·5
13	19·5	24	25	41·5	145	1·1	L	29	47	13·4	58	16·5	17
8	14	20	22·5	40	135	·8	L	30	37	10·4	50	14·8	16·5
3	12	14·5	16·5	26·5	88	1·	L	30	45	13·6	55	16·5	18·5
9	15·5	19	20	32·5	112	·5	L	29	48	13·8	58	17	18
11	14·5	20·5	23·5	37·5	132	...	...	28	39	11	55	15·5	18
5	13·5	17	18	32·5	100	...	...	33	42	13·5	52	17	18
10	17	21·5	23	38·5	126	1·6	R	31	44	13·5	56	17·1	18
10	16·5	21·5	23·5	40·5	138	·8	R	29	41	12	53	15·6	17
12	17	23	26	45	154	·6	L	29	38	11	51	14·9	17
3	13·5	16·5	17·5	29·5	95	1·1	R	31	46	14·2	56	17·4	18·5
13	16	21	27·5	44·5	141	...	...	32	36	11·3	47	14·9	19·5
6	13·5	18·5	20	34·5	118	...	...	29	39	11·4	54	15·7	17
7	14·5	18·5	20·5	37	121	·5	L	31	39	12	50	15·3	17
10	16·5	21·5	22·5	41·5	136	1·	R	30	40	12·1	52	15·8	16·5
14	19	23·5	26·5	43	149	...	...	29	44	12·8	55	15·8	18
13	19	22·5	24·5	42·5	137	1·6	L	29	45	13·9	53	16·4	18
8	16·5	20	21·5	37	123	·6	L	31	45	13·4	54	16·3	17·5
8	15	20	22·5	39	124	·6	R	31	38	12·1	51	16·1	18
2½	12	15	16	27	89	...	...	30	44	13·5	56	16·8	18
6½	12·5	16	17·5	32·5	108	...	...	30	38	11·6	49	14·8	16
11	16	20	23	38	129	·9	L	29	42	12·4	53	15·5	18
11	16	21·5	24	40·5	137	...	...	30	39	11·7	53	15·7	17·5
1½	10	12·5	14·5	23·5	77	...	...	31	43	13	53	16·2	19
2¼	10·5	13	14·5	25·5	79	·5	L	32	41	13·3	51	16·5	18·5
3	11·5	14	17	30	92	...	...	33	38	12·5	47	15·2	18·5
3	12	14	16·5	28·5	89	·6	L	32	42	13·5	49	15·7	18·5
4	14	17	17·5	28	94	·6	L	30	50	14·9	61	18·1	18·5
12	15·5	21	22·5	39·5	128	·8	R	31	39	12·1	53	16·4	17·5
12	17·5	23·5	27	35	133	...	...	26	50	13·2	67	17·7	20
10	14·5	20·5	23	36·5	133	...	...	27	40	10·9	56	15·4	16·5
2½	10·5	12·5	14·5	24·5	77	...	...	32	43	13·6	51	16·2	19
13	20	25·5	27·5	46·5	149	1·6	L	31	43	13·4	55	17·1	18·5
14	16	21	23·5	42·5	132	·6	R	32	38	12·1	49	15·9	18
10	17	21·5	25	42·5	136	...	...	30	40	12·5	51	15·8	18 5
11	17	21	21·5	38	125	...	...	31	45	13·6	55	16·8	17
6	15	18·5	20·5	34·5	116	·5	R	30	43	12·9	54	16	17·5
11	13	16·5	18	34·5	107	2	R	32	38	12·2	48	15·4	17
8	15·5	20	22	34	118	·6	R	29	46	13·1	59	16·9	18·5
6	14	16·5	17	31·5	101	...	...	31	45	13·9	52	16·3	17

Adult Males.

Age.	Interspinous diameter.	Intercristal diameter.	Intertrochant. diameter.	Vertical trunk diameter.	Height.	Diff. in sides.	Greater side.	Index No.						
								1.	2.	3.	4.	5.	6.	7.
87	24	30·5	32·5	46·5	165	·5	R	28	52	14·5	66	18·5	19·5	79
73	22·5	26·5	28·5	48·5	168	1·8	L	29	46	13·4	55	16	17	85
61	19	27	30·5	53	175	...	...	30	36	10·9	51	15·5	17·5	70
55	20·5	28·5	32	50·5	167	...	...	30	41	12·3	56	17	19	72
67	23	27·5	31	55·5	174	...	...	32	41	13·2	50	15·8	18	84
77	22·5	31·5	33	50	169	...	...	30	45	13·3	63	18·5	19·5	71
41	23	29·5	31	49	158	...	...	31	47	14·5	60	18·5	19·5	78
76	22	28·5	31·5	47	165	..	...	28	47	13·3	61	17·3	19	77
87	21·5	29·5	31·5	52·5	164	...	...	32	41	13·1	56	18	19	73
62	22·5	30·5	33	51·5	173	...	...	30	44	13	59	17·6	19	74
90	24	29·5	...	48·5	165	1·3	L	29	49	14·5	61	17·9	...	81
82	21·5	29·5	31	50	169	...	...	30	43	12·7	59	17 4	18·5	73
56	22·5	27·5	31·5	47·5	161	1·1	L	30	47	14	58	17·1	19·5	82
62	22·5	30	33·5	48	166	·7	L	29	47	13·5	63	18·1	20	75
73	23·5	30	33	50	164	...	...	30	47	14·3	60	18·3	20	78
55	24	30	30·5	52	173	·8	L	30	46	13·9	58	17·3	17·5	80
29	23	30	33·5	51	178	...	...	29	45	12 9	59	16·8	19	77
38	21·5	29·5	32	48	167	...	...	29	45	12·9	61	17·7	19	73
18	23	31·5	33·5	57·5	184	...	...	31	40	12·5	55	17·1	18	73
46	22	31	33·5	52	176	1·6	R	30	42	12·5	60	17·6	19	71
54	22	29·5	33·5	49	180	1·4	L	27	45	12·2	60	16·4	18·5	75
59	22·5	31	33·5	51	172	1·9	L	30	44	13·1	61	18	19·5	73
50	22·5	28	31	51·5	175	...	...	30	44	12·8	54	16	17·5	80
75	22·5	27·5	29·5	50·5	165	1	L	31	45	13·6	54	16·7	18	82
25	20·5	28	31	53·5	176	·9	R	30	38	11·6	52	15·9	17·5	73
31	22·5	29	31·5	53	163	1	L	33	43	13·8	55	17·8	19 5	78
42	23	27	29	47·5	159	1·6	L	30	48	14·5	57	18·1	18	85
45	24·5	30·5	34·5	52·5	176	...	...	30	47	13·9	58	17·3	19·5	80
23	23·5	29	32	50	167	...	...	30	47	14·1	53	17·4	19	81
21	21·5	28	31·5	50·5	168	1·4	L	30	43	12·8	55	16·7	19	77
54	22·5	28·5	31	51	172	...	...	30	44	13·1	56	16·6	18	79
60	22·5	29	32	51·5	174	1·9	L	30	44	12·9	56	16·7	18·5	78
47	26	32	34	56·5	171	1·8	R	33	46	15·2	57	18·7	20	81
47	22	29	33	53·5	169	·5	L	32	41	13	54	17·2	19·5	76
25	21	28	31·5	50	173	...	...	29	42	12·1	56	16·2	18	75
22	22	29	31	55	181	1·5	L	30	40	12·1	53	16	17	76
24	22·5	28·5	31	50	169	...	...	30	45	13·3	57	16·9	18·5	79
35	22·5	29	31·5	45	157	...	...	30	50	14·3	64	18·5	20	78
69	21·5	29	32·5	56·5	181	...	...	31	38	11·9	51	16	18·5	74
19	23·5	28	31	55	181	·5	L	30	43	13	51	15·5	17	84
22	22·5	28·5	31·5	50	173	·6	R	29	45	13	57	16·5	18	79
27	20·5	27	31	50·5	165	...	...	31	41	12·4	53	16·4	19	76
19	21·5	27	31·5	52	183	...	...	28	41	11·7	52	14·7	17	80
18	18·5	27	31·5	51·5	173	...	...	30	36	10·2	52	15·6	18·5	69
20	19	27	31	50·5	172	1·1	R	29	38	11	53	15·7	18	70
23	21·5	27	32	50·5	172	...	...	29	43	12·5	53	15·7	18·5	80
20	22·5	28·5	32·5	51·5	174	...	...	30	44	12·9	55	16·4	18·5	79
20	22	29	33	53	182	1	R	30	42	12·1	55	15·9	18	76
22	21	28	33·5	56	181	...	...	31	38	11·6	50	15·5	18·5	75
20	21	27·5	31·5	52	172	...	...	30	40	12·2	53	16	18·5	76

Adult Females.

Age.	Interspinous diameter.	Intercristal diameter.	Intertrochant. diameter.	Vertical trunk diameter.	Height.	Diff. in sides.	Greater side.	Index No.						
								1.	2.	3.	4.	5.	6.	7.
24	22	27	34	44·5	150	1	R	30	50	14·7	61	18	22·5	81
16	22	28·5	32·5	48	157	1	R	31	46	14	59	18·1	20·5	77
42	22	28	32	42	157	·7	L	27	52	14	62	17·8	20·5	79
31	21	26·5	29·5	48	146	...	...	33	44	14·4	55	18·1	20	79
34	23·5	27	31·5	48·5	161	...	...	30	48	14·6	56	16·8	19·5	87
18	21	29 5	32	47·5	162	1·6	L	29	44	13	62	18·2	20	71
17	18	26	31	46	163	1·8	L	28	40	11	57	15·9	19	69
24	21	28·5	30·5	39·5	157	...	...	25	53	13·3	64	18·1	19·5	74
18	20·5	25·5	29·5	44	150	...	...	29	47	13·7	58	17	19·5	80
27	22·5	28·5	30·5	46·5	152	1·2	L	31	48	14·8	61	18·7	20	79
22	24	28·5	33·5	50·5	164	1·9	R	31	48	14·6	56	17·4	20·5	84
26	19·5	25·5	32	46·5	151	1·2	L	31	41	12·9	55	16·9	21	76
31	23	27·5	32·5	49·5	156	1·3	L	32	46	14·7	56	17·6	21	84
28	22	26	31	48·5	162	1·8	L	30	45	13 6	54	16	19	85
21	25·5	29	34	51	159	...	...	32	50	16	57	18·2	21·5	88
20	21	26·5	29	50	154	·8	L	32	42	13·6	53	17·2	19	79
37	25	31·5	33·5	48	166	1	L	29	52	15·1	66	19	20	79
26	18·5	26·5	30	50	156	·7	L	32	37	11·9	53	17	19	70
26	21	28·5	31·5	52	170	·5	R	31	40	12·3	55	16·8	18·5	74
30	18·5	28	31	50·5	166	...	...	31	36	11·1	55	16·9	18·5	66
33	24·5	31·5	33	50	159	1·7	L	31	49	15·5	63	19·8	21	78
21	22	29·5	34	52	161	·5	R	32	42	13·7	57	18·3	21	75
19	20	26·5	30·5	48·5	160	...	...	30	41	12·5	55	16·5	19	75
23	23	28·5	30	46·5	162	...	...	29	49	14·2	61	17·6	18·5	81
30	18·5	25·5	29·5	46	141	1·6	L	33	40	13·1	55	18·1	21	73
18	22	30·5	36·5	45·5	164	1·3	L	28	48	13·4	67	18·6	22	72
82	25·5	30	33	46·5	152	...	...	31	55	16·8	64	19·7	21·5	85
30	22	27·5	33	51	164	·6	R	31	43	13·4	54	16·8	20	80
40	19·5	28·5	34	52	165	1·1	R	32	38	11·8	55	17·3	20·5	68
24	23	29	33·5	52	160	...	...	32	44	14·4	56	18·1	21	79
29	21	28·5	32	47	154	1·1	R	30	45	13·6	61	18·5	21	74
32	19·5	24·5	29	44	148	·8	R	30	45	13·2	56	16·5	19·5	80
38	19·5	26	30·5	49	156	·5	R	31	40	12·5	53	16·7	19·5	75
28	19	24	27·5	43	146	1·3	L	29	44	13	56	16·4	19	79
19	23	29	31·5	49·5	162	1·5	L	30	46	14·2	59	17·9	19·5	79
39	22	26·5	32·5	47 5	153	...	...	31	45	14·4	56	17·3	29	83
21	22	28·5	34	50	160	...	...	31	44	13·7	57	17·8	21	77
18	20·5	29	30·5	48·5	146	2·2	R	33	42	14	60	19 9	21	71
31	22	28·5	31	46·5	158	·5	R	29	47	13·9	61	18	19·5	77
21	22·5	27·5	30	45·5	149	...	...	31	47	15·1	60	18·4	20	82
18	18·5	27	30·5	47	157	·9	R	30	39	11·8	56	17·2	19·5	69
26	19·5	24	29·5	46·5	148	...	...	31	42	13·2	57	16·2	20	81
20	20	26·5	31·5	47·5	162	...	...	29	42	12·3	56	16·4	19·5	75
30	22·5	30	32	53	163	1·6	L	33	42	13·8	57	18·4	19·5	75
30	22	28·5	31	52	159	...	...	33	42	13·8	55	17·9	19·5	77
20	22	29	30·5	48·5	157	·9	R	31	45	14	60	18·5	19·5	76
19	21	28·5	31·5	46·5	163	...	...	29	45	12·9	61	17·5	19·5	74
22	20·5	29	33·5	50·5	159	...	...	32	41	12·9	57	18·2	21	71
21	19	26	31	46·5	153	...	...	30	41	12·4	56	17	20	73
70	24·5	29	32	50	159	·6	L	31	49	15·4	58	18·2	20	84
70	23·5	29	32	50	154	3·5	L	32	47	15·2	58	18·8	21	81

ADDISON'S CASES. BERRY'S CASES.

(27) MALES.				(11) FEMALES.				(22) MALES.				(13) FEMALES.			
Age.	Vertical trunk diameter.	Interspinous diameter.	Index No. 2.	Age.	Vertical trunk diameter.	Interspinous diameter.	Index No. 2.	Age.	Vertical trunk diameter.	Interspinous diameter.	Index No. 2.	Age.	Vertical trunk diameter.	Interspinous diameter.	Index No. 2.
52	50	27	54	60	50	24	48	60	52	26	50	30	48	25	52
55	52	23	44	71	52	25	48	44	54	20	37	74	46	24	52
59	54	21	39	55	52	20	38	47	52	24	46	48	53	22	42
47	52	23·5	45	39	52	23	44	48	53	26·5	50	64	52	24	46
36	49	20	41	39	52	24	46	61	54	24	44	38	48·5	20	41
59	55·5	25	45	55	50	24	48	55	51·5	26	50	84	45·5	25·5	56
66	55	28	51	40	48	24	50	60	57	25	44	69	50	26	52
30	55	28	51	35	50	22	44	80	52	24	46	50	54	24	44
50	55	24	44	43	46	23	50	55	47	24	51	74	48	24	50
52	49·5	23	46	35	51	25	49	63	54	24	44	68	54	25	46
40	52	24	46	64	48	23	48	69	52	24	46	66	49·5	23	46
61	52	24	46					65	50	24	48	77	51	22	43
45	56	27	48		cm.	cm.		70	50	25	50	20	48	24	50
31	52	23	44	Mean	50·09	23·36	46·64	66	51	24	47				
24	52	25	48					60	47	25·5	54		cm.	cm.	
35	54	25	46					72	53	26	49	Mean	49·92	23·77	47·69
29	54	24	44					28	53	27	51				
29	52	24	46					57	56	20	36				
42	52	22	42					60	53	23	43				
63	52	26	50					66	56	24·5	44				
38	52	19	37					46	52	20	38				
65	54	25	46					66	56	26	46				
64	58	28	48												
35	52	23	44						cm.	cm.					
35	56	26	46					Mean	52·55	24·27	46·09				
55	54	22	41												
65	54	25	46												
	cm.	cm.													
Mean	53·19	24·26	45·48												

Mean height	167·64 cm.	154·48 cm.
Mean index—		
No. 1	31·73 ,,	32·42 ,,
,, 3	14·47 ,,	15·12 ,,
,, 4	55·83 ,,	58·27 ,,
,, 5	16·99 ,,	18·48 ,,

Addison's and Berry's cases combined :—

	(49) Males.	(24) Females.
Vertical trunk diameter	52·9 cm.	50 cm.
Interspinous diameter	24·27 ,,	23·58 ,,
Index No. 2	45·75 ,,	46·92 ,,

Note.—Berry's cases hitherto unpublished. Addison's figures were taken from his paper, and the vertical trunk-body height index was prepared by Professor Berry.

OBSERVATIONS UPON YOUNG HUMAN EMBRYOS.

By J. T. WILSON, M.B., F.R.S., *Challis Professor of Anatomy in the University of Sydney, Australia.* (With Three Plates.)

Part I.

The appearance in recent years of Keibel and Mall's *Manual of Human Embryology* (1), following upon Keibel and Elze's *Normentafeln* (2), marked an epoch in the formulation of our knowledge of specifically human development.

The comprehensive summary there offered of our knowledge of the earlier human ontogenetic processes provided for the first time a more or less connected account of these phenomena, but it also served to accentuate the still very sketchy and incomplete character of that knowledge.

Much of our belief in regard to the method of establishment of the human blastocyst is still quite hypothetical, even if probable; and as regards the appearance of the earliest rudiments of the body itself, our knowledge is based on a very few human specimens separated by intervals which it is important to fill in with the aid of intermediate or allied stages.

In the present paper I propose to give an account of the three youngest human embryos in my collection.

Previous writers have described and figured specimens of a stage of development more or less similar to those exhibited by the two older of the embryos which form the subject of this communication. Nevertheless, well-preserved specimens, of ages nearly corresponding to these, are of such comparative rarity that for some time to come it will still be desirable to have accurate records published of the form and structure of any that may become available for detailed examination. As a matter of fact, no two specimens hitherto described, however apparently similar in stage of development, have proved to be precisely identical in detail. It will appear in the course of the paper that each of the individual embryos under consideration presents features entitling it to independent description.

A more special interest attaches to the youngest of the three specimens, inasmuch as it would seem to exhibit a phase of development hitherto unrepresented in the records of early human embryos.

It possessed probably two, possibly three, pairs of somites, and may thus

be determined as occupying a position in the gap between stages 2 and 3 of Keibel and Elze's *Normentafel*. These stages are represented respectively by Spee's embryo "Gle" (3), and the Kroemer-Pfannenstiel embryo "Klb."

Hitherto, or as far as I am aware, no human embryo has been recorded as exhibiting a smaller number of somites than five (in "Klb").

I am inclined to believe that the embryo "E," No. 1 of His' *Normentafel* (4), would have turned out to be of very similar character to that now about to be described, in spite of the somewhat greater length of the former (2·1 mm. as against 1·68 mm.).

Eternod's well-known embryo of 1–3 mm. (his "No. 7 Vuill.") (5) may well represent a somewhat earlier phase.

The youngest embryo now to be described—the first of the three referred to—appears in my list of human embryos under the designation of "Hdr." I shall, however, refer to it in future simply under its catalogue number "H 3."

History of Human Embryo "H 3."[1]

The specimen was received by me so long ago as 25th May 1898, from my late friend Dr H. V. C. Hinder of Sydney, who had obtained it from a case of abortion on the previous day. The unopened chorionic vesicle had been placed in diluted alcohol. It was to outward appearance well conserved and perfectly intact when I received it, and it was at once transferred to picrosulphuric acid and then passed through graded alcohols.

From notes procured at the time by my friend Dr A. E. Mills, who was also associated with the case, it appears that the last menstruation period had begun on 12th April 1898 and ended on 16th April 1898. Abortion actually took place on 24th May 1898, but hæmorrhagic discharge had appeared on 22nd May 1898. Thus the period that had elapsed since the beginning of the last menstruation up to the commencement of abortion was 40 days, or 36 days from the end of the last menstruation. The period that had elapsed since the due date of the lapsed menstrual period was 12 days.

According to present-day criteria the age of this embryo may be estimated as included in the period 18–21 days, and probably in the earliest part of this period.[2]

[1] A lantern demonstration of slides of this embryo was given at a meeting of the Anatomical Society of Great Britain and Ireland at a meeting held on 16th January 1914.

[2] Keibel and Elze (*Normentafel* (2), p. 90) quote Born's estimate of the age of embryo "Klb" as 10–14 days. But if we take into account the more recently accepted criteria of age in early embryos, this age must be judged to be considerably underestimated. I shall show reason to regard embryo "Klb" as distinctly more advanced in development than embryo "H 3."

As originally received by me, the specimen was to all appearance in excellent condition. No defect in its preservation was recognisable throughout the period of its examination as an entire specimen prior to embedding, except that a portion of the yolk-sac was accidentally broken away during manipulation.

After embedding in paraffin a complete series of sections at 10 μ was obtained. Unfortunately the histological condition of the sections was most disappointing. The attempt at an adequate fixation must, after all, have been too belated. Possibly also there may have been some overheating in the paraffin oven. So unsatisfactory was the result at the time, that after a somewhat cursory examination the series was put aside for a considerable number of years. Now, however, on re-examination in connexion with the investigation of more recent specimens, it has appeared to me to be well worth while to describe this early embryo in some detail. More especially perhaps do the photographic records of the entire specimen, which shows no external sign of structural deterioration, constitute original documents of some value for comparative purposes. And even the sectional series, although not fully adequate for the purposes of plastic reconstruction, turns out, on closer examination, to be of no little interest and value.

Characters and Dimensions of Chorionic Vesicle.

The chorionic vesicle of "H 3" is illustrated in the photograph reproduced in Pl. I. fig. 1, which was taken after the vesicle had been rendered transparent in cedar oil. It was flattened in its polar axis and measured 5 mm. in its (practically avillous) polar diameter. Its equatorial diameter was about 8·5 mm., inclusive of the villi; or, without villi, 6·4 mm. in its longer and 5·7 mm. in its shorter equatorial diameter.

The chorionic dimensions were thus rather smaller than those of Spee's embryo "Gle" and almost identical with those of His' embryo "E."

As just indicated, the villi were unequally distributed over the surface of the vesicle. There was a richer equatorial villous zone, whilst the polar areas were freer from villi, though at no place completely bald. One of the polar areas, the antembryonic, was barer than the other.

The villi showed a very moderate degree of branching (*cf.* Pl. I. fig. 1).

After having been examined and photographed from both polar aspects, the vesicle was opened and the portion of its chorionic wall carrying the attachment of the body-stalk was separated from the rest. The embryonic rudiment with its associated appendages was then subjected to closer examination and sketched and photographed from various points of view. (Pl. I. fig. 2, taken in cedar oil; also text-figs. 1–3.)

Micrometer Measurements.

The following micrometer measurements were obtained of the embryo and its immediate appendages. The measurements were taken while the specimen was in cedar oil.

Maximum cranio-caudal length of amnion . .	1·78 mm.
Maximum „ „ yolk-sac . .	2·26 „
Apparent „ „ embryo . .	1·64 „
Dorso-ventral extent of amniotic cavity from its dorsal convexity to line of reflection of somatopleure in the head region	0·6 „
Dorso-ventral extent of yolk-sac	1·66 „

N.B.—The yolk-sac was partly collapsed and crumpled, as shown in the photograph (fig. 2).

The specimen was next embedded in paraffin and cut in series of 10 μ sections in a plane intended to be transverse to the long axis of the embryo, but which turned out to be distinctly oblique. The sections constitute a practically unbroken series, but their histological condition is not very satisfactory. They are tolerably well stained in hæmatoxylin. The series was both cut and numbered in caudo-cranial succession. When the sections and figures are viewed with the dorsal embryonic surface away from the observer, the right and left embryonic surfaces are right and left, respectively, to the observer.

Form and Characters of Embryo and its Appendages.

In Pl. I. fig. 2 the embryo, along with its immediate appendages, amnion and yolk-sac, is seen attached to a fragment of the chorion by the body-stalk. The latter is rather acutely reflexed in a cranial direction, thus arching over a considerable extent of the amnion so as to form the actual roof of the caudal portion of that cavity. The serial sections, when followed from behind forwards, show that the amnion only gradually becomes free from superincumbent cellular tissue of the stalk. Rather more than the caudal third of the amnion is thus intimately connected with the body-stalk, whose vascular mesodermal tissue, indeed, spreads out over this portion of the amnion like a hood.

The lateral portions of this hood gradually thin out as they clothe the sides of the amnion. In consequence of this extension of body-stalk tissue over the sides of the amniotic sac, the amnion exhibits in this region the appearance of a more or less vascular membrane (text-figs. 4 and 5).

Within the amniotic chamber the outline of the embryo may be

discerned (Pl. I. fig. 2), with its cephalic expansion elevated bilaterally into two prominent medullary folds, separated by a deep and wide medullary groove (*cf.* text-fig. 6).

There is either no dorsal flexure or kink of the embryonic body, or only a faint indication of one (*cf.* text-fig. 1).

Behind the broad cephalic region the embryo shows marked constriction and then appears to widen out into a foliate expansion, which forms the hinder third of the apparent embryonic body.

The superficial appearance of the foliate expansion suggests a widening and opening-out of the medullary plate in this region. This, however, is not the exact condition met with. The still widely open neurenteric aperture, text-fig. 7, is situated near the junction of the middle and posterior thirds of the embryonic region. Its position nearly coincides with the ventrally open angle recognisable in Pl. I. fig. 2, and also in text-fig. 1, at *b*, where also an arrow points to the site of the neurenteric aperture. The open angle at *b* in text-fig. 1 really marks the anterior limit of the leaf-like expansion of the hinder part of the embryonic region. Immediately in front of the neurenteric aperture, the sections show the medullary plate as still markedly infolded so as to form a deep and not very wide medullary groove.

Behind the aperture there is no shallowing out, but, on the contrary, the primitive-streak formation is here actually depressed into a deep cleft which continues backwards between two elongated, bolster-like, caudal swellings containing mesoderm (text-fig. 5).

It is these caudal swellings which form the lateral wings of the posterior foliate expansion of the embryonic region. The ectoderm covering them is not at all, or only slightly, thickened, whilst the primitive-streak ectoderm lining the deep dorsal furrow between them is thick and columnar like that of the medullary plate in front.

Apart from the elongated caudal cushions bounding the deep sulcus in the primitive-streak region, there is no posterior tail-prominence. The part of the embryonic region containing the caudal swellings is, however, placed slightly at an angle with the rest of the embryonic area. This may be recognised in the photograph, fig. 2, Pl. I., and is well shown in the outline in text-fig. 1.

The caudal cushions gradually fade away posteriorly in the floor of the hinder region of the amniotic cavity. This latter tapers into a narrow-pointed prolongation and ends at the plane of the hinder limit of the root of the body-stalk. It has no continuation into the body-stalk. Its floor is formed solely by the continuation backwards of the floor of the vanishing primitive groove (text-fig. 8).

Close to the termination of the amniotic cavity there is a thick "cloacal membrane" connecting with the entoderm at the base of the allantoic duct (text-fig. 9). The position of this cloacal membrane may be compared with that described and figured recently by Grosser in a younger embryo (8, Taf. 27). There was no caudal stalk-like prolongation of the amnion, other than the above, to correspond with that described by Eternod in his 1·3 mm. embryo.

As there is no tail-prominence proper, the posterior limit of the embryo has been reckoned as if coincident with the hinder limit of the furrowed primitive-streak region, although the extremity of the future tail would undoubtedly be formed by hypertrophy of the bilateral caudal cushions far in front of this point. Reckoning, then, from the posterior limit of the primitive-streak region to the cranial limit of the cephalic medullary plate, the length of the embryonic area included 143 sections at 10 μ. In the table

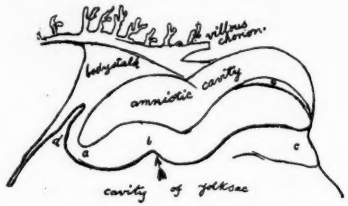

FIG. 1.—Outline showing profile view of embryo "H 3."

of measurements the apparent length of the embryo prior to embedding was 1·64 mm.; the difference just indicated is doubtless to be accounted for mainly by shrinkage during embedding.

In text-figs. 1, 2, and 3 are reproduced the outlines of freehand sketches, from various points of view, that were made in the course of examination of this embryo, *in toto*, in cedar oil.

Text-fig. 1 is the outline of a nearly profile view. It may be looked at along with the photograph, fig. 2, Pl. I., which represents a dorso-lateral view of the specimen. The text-figure shows the degree of vertical curvature of the several regions of the embryo. The approximate position of the neurenteric aperture is indicated by the arrow. The region *a* to *b* is the primitive-streak region: the angle of its inclination to the main embryonic axis is to be noted.

If this figure be compared, *e.g.*, with figs. 19 and 20 of Eternod's monograph *L'œuf humain* (5) (Genève, 1909), illustrating respectively Selenka's outline figure of *Hylobates Rafflesi*, and Eternod's outline of his 1·3 mm. human embryo ("No. 7 Vuill."), it will be seen that the most outstanding

difference is due to the acute ventral flexure of the primitive-streak region in these embryos as compared with my specimen "H 3." And this difference in flexure is correlated with the difference observable in relative position of the body-stalk. The absence of a ventral flexure of the primitive-streak region in embryo "H 3" permits of a rather acute reflexion, in a cranial direction, of the body-stalk.

Practically the same comparison may be made with embryo "Klb" (Kroemer-Pfannenstiel) of Keibel and Elze's *Normentafel* (2), which possessed 5–6 pairs of somites and must represent a somewhat similar developmental phase to that of the embryo under consideration. That "Klb" was slightly more advanced is indicated by its possession of a well-marked tail-prominence, of a closed-in hind-gut, and by several other features to be later commented upon.

The possibility cannot be entirely excluded that the extended position of the hinder part of the embryonic area of "H 3" is somewhat abnormal, especially as the flexed attitude of the primitive-streak region was already attained in Spee's embryo "Gle" (3), which is certainly less advanced and is probably perfectly normal.

In any case, it is plain that the absence of ventral flexion of the primitive-streak region in "H 3" involves a reconsideration of the true length of the embryo. If a reliable comparison is to be instituted with other human embryos of approximately the same stage, then we must deduct from the apparent embryonic length given above as 1·64 mm., nearly the whole length of the primitive-streak region behind the neurenteric aperture, since, in the embryos referred to, the neurenteric aperture lies quite close to the angle of a ventrally flexed tail-end of the embryonic body.

The deduction here suggested as necessary includes nearly the whole of the primitive-streak region. In the total of 143 sections of the embryonic area, inclusive of primitive streak, no fewer than 47 lie behind the plane of the caudal boundary of the neurenteric aperture.

Allowing for the slight caudal convexity behind this which is recognisable in comparable embryos, I estimate the true "embryonic length," for comparative purposes, to have been not over 1·25 mm. The actual proportion of the total of 1·64 mm. *in front of* the neurenteric aperture is almost exactly 1 mm.

Text-fig. 2 represents the outline of embryo "H 3," as viewed from above and slightly from the caudal direction. The irregular area which has been hatched in the drawing represents the small portion of chorion connected with the body-stalk. The stippled area represents the dorso-caudal aspect of the body-stalk, and shows how it spreads out laterally over

the hinder portion of the amniotic sac. Some indications of the chorio-placental vessels may be noted, but their detailed arrangement has not yet been worked out from the sections.

Text-fig. 3 represents an outline sketch giving the frontal "elevation" (Norma frontalis) of the amnion and head of the embryo, as viewed from

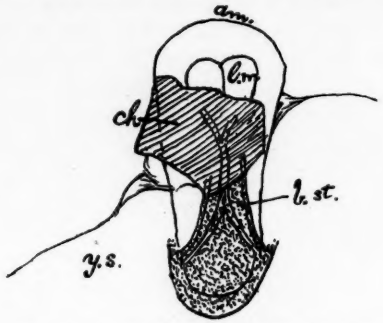

FIG. 2.—Outline showing caudo-dorsal view of embryo "H 3."

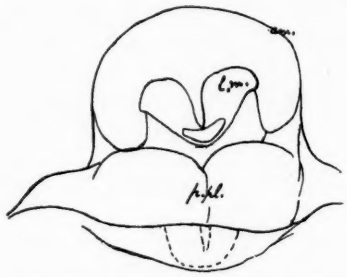

FIG. 3.—Outline showing norma frontalis of embryo "H 3."

the front and very slightly from the ventral side. The wide bulging area below the amniotic sac corresponds to what may be termed the "pericardial plate," although at the present stage the pericardium does not actually reach quite to its surface.

Mesodermal Somites.

Notwithstanding careful and prolonged examination of this embryo while in cedar oil prior to embedding, I was unable to detect the presence of differentiated somites. The other features of the embryo seemed to indicate that some at least of the earliest somites should be already in existence.

Examination of the serial sections has, in fact, confirmed this conjecture. Unfortunately, the histological condition of the paraxial mesoderm is not so satisfactory as to permit of a wholly reliable determination of the number of somites represented. I have only been able to recognise in the section series one line of segmental cleavage with tolerable certainty. I dare not assert that it is the only one present, and a critical examination of good silver prints of the photograph here reproduced on Pl. I. fig. 2 suggests the possible existence of up to three pairs of somites.

In any case, it is evident from the photograph in question that the number of somites could only have been small. And in this connexion it must be pointed out that only a distance represented by about 25 sections intervenes between the tolerably abrupt posterior limit of the crescentic curve of the cephalic medullary fold and the anterior margin of the neurenteric aperture.

The distance between the probably corresponding points in the second of my specimens, "H 98," which possesses 9–10 pairs of somites, includes no fewer than 65 sections of similar thickness.[1]

We have therefore to reckon in embryo "H 3" with 25 sections, against 65 in the latter stage ("H 98"), as representing the possible longitudinal field of somite differentiation.

Now, an inspection of figures of other early embryos suitable for comparison will show that the differentiated somites do not extend close up to the anterior, and certainly not nearly to the posterior, limits as above defined, so that we have to deal with a lesser number than 25 sections, which could pass through mesodermal primitive segments.

In the Kroemer-Pfannenstiel embryo, for example (fig. 111D of Taf. I., Keibel and Elze's *Normentafel* (2)), the five pairs of somites there present do not occupy much more than half the distance between the neurenteric aperture and the hinder end of the cephalic medullary plate. From their figure it would appear that the distance from the cranial limit of the first pair of somites to the neurenteric aperture was about ·7 mm., and the actual segmented zone occupied only about 0·35.

Inasmuch, then, as in embryo "H 3" the entire available length from cephalic medullary plate to neurenteric aperture is represented by only about 25 sections, the actual segmented portion was quite probably not more than about half of that length—say 12 or 13 sections in extent.

I find in the older embryo "H 98" that the somites there met with

[1] It is perhaps necessary here to point out that although in the latter embryo the neurenteric aperture was closed, yet it is quite easy to determine the site corresponding to it, for here the chorda merges in mesoderm which cuts into the overlying medullary plate like an inverted keel (text-fig. 10).

extend over an average distance of about 5 sections each. If, as is highly probable, there is no great increase in size of the individual somites in these early stages, the conclusion may be drawn that only two, or at most three, pairs of somites could possibly have been differentiated in embryo "H 3."

I have already stated that one cleavage line may be definitely established in the sectional series. I can find no positive evidence in the series of any other, and I see little reason to doubt that here we have an example of a human embryo at about the stage of progressive differentiation of the first two, or possibly three, pairs of somites.

Chorda.

The chorda is still in the stage of intercalation in, and is indistinguishable from, the entoderm.

Not only is there no chorda as such, but there is no unequivocal indication of strict delimination, even of a chorda-plate, except for a distance of 3 or 4 sections immediately in front of the neurenteric canal. It is possible that in the pharyngeal region the longitudinal zone of entoderm, which covers the dorsal median prominence, due to the grooved medullary plate, may actually represent definite chorda-entoderm. But, except that a median strip of entoderm *is* thus more or less accidentally delimited, there is nothing to suggest the specific character of just that precise area. Text-fig. 13 illustrates the 4th section in front of the anterior margin of the neurenteric aperture. Even here the chorda-plate is evident, not so much by its differentiation from the rest of the entoderm, as by the appearance here of an entodermal indentation which leads caudally into the neurenteric opening itself.

Excretory Apparatus.

There is no ascertainable pronephric rudiment, nor would one expect to find any at this early stage. In any case, the histological conditions are unfavourable to any critical verification.

Medullary Plate.

The general characters of the medullary plate have already been alluded to in connexion with the form of the embryo. Pl. I. fig. 2, along with text-figs. 1, 2, and 3 and the various sectional text-figures, will sufficiently illustrate its present phase of development. The photomicrographic text-fig. 18 will further elucidate its structural arrangement so far as its rather poor histological condition will allow. Text-fig. 4 illustrates the appearance of the medullary plate and groove a short distance (4–5 sections) caudal to the cephalic expansion of the plate, and 21 sections in front of the anterior

lip of the neurenteric aperture. Nowhere is there any closer approximation of the medullary folds than is shown in this section.

The histological conditions are not favourable enough for reliable observations either on neuromeric segmentation or on neural crest formation.

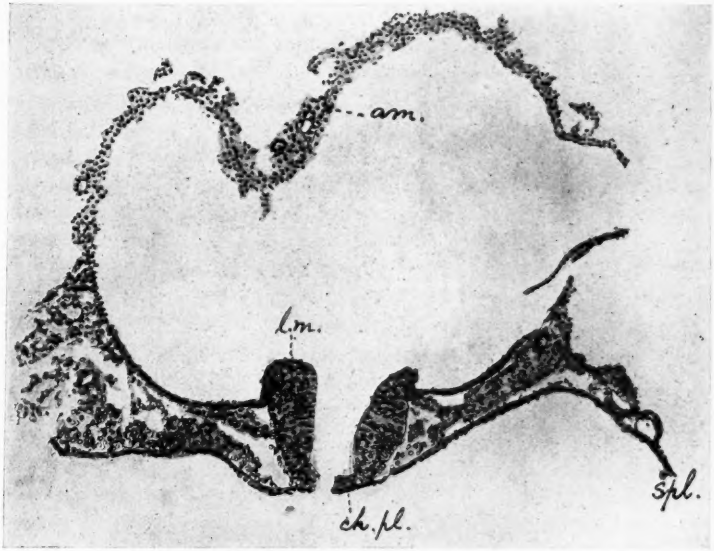

FIG. 4.—Section 95 of embryo "H 3."

Absence of Sense Organs.

There is no trace whatever of optic groove formation nor of auditory areas, although there is a diffuse and rather extensive thickening of the head ectoderm in the posterior cephalic region, which may possibly foreshadow the appearance of such areas.

Oral Region.

On the ventral aspect of the head, immediately in front of the line of reflexion of the ectoderm from the free head to the "pericardial plate" swelling (text-fig. 11), the ectoderm forms a plate, slightly recessed bilaterally, the depressions being separated from one another by a slight median prominence.

This gently recessed area alone represents the oral sinus (stomodæum), which is thus very imperfectly formed.

The ectoderm of this oral sinus is separated from the entoderm of the pharynx by abundant mesoderm. Nowhere do ectoderm and entoderm even closely approach one another, so that the "primary pharyngeal membrane" is here quite thick (0·06 mm.), and composed of all three germ layers. In fact, the mesoderm is here disposed as a specially thick compact mass of cells between the ectoderm and entoderm (text-fig. 11), and is continued backwards as such to the very caudal limit of the region of

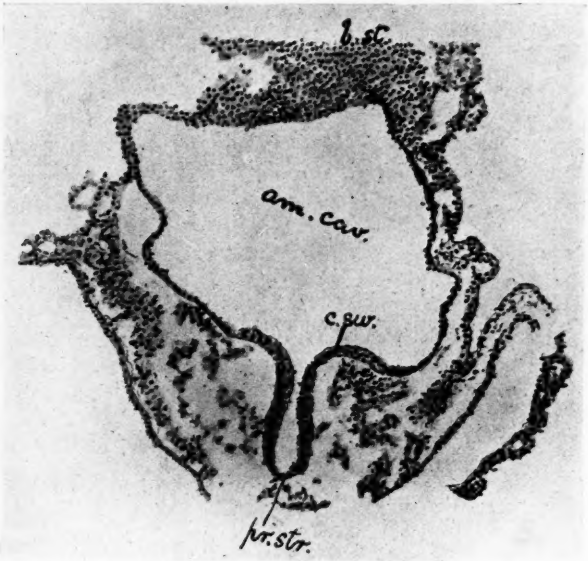

FIG. 5.—Section 49 of embryo "H 3."

the rudimentary oral sinus. The area of this imperfectly formed oral sinus extends through sections 159–153 inclusive.

There are no evidences of any hypophysial formation.

Alimentary Canal.

The fore-gut shows a general agreement in character with that of the important Kroemer-Pfannenstiel embryo "Klb" of Keibel and Elze's *Normentafel.* The pharynx of this embryo has been described, modelled, and figured by Grosser (6) (also in the Keibel-Mall *Manual,* vol ii. pp. 446–7). In embryo "H 3" the fore-gut is closed in for a distance represented by 30 sections, in front of the plane of its continuity with the

yolk-sac at the "Darmpforte." In the "Klb" embryo, the fore-gut was closed in throughout the extent of 32 sections. Grosser states (6) that its actual length, allowing for curvature, was 400 micra. The fore-gut in "H 3" represents the anterior portion of the future pharynx. It has the usual laterally expanded form (text-fig. 6). It gradually diminishes in width when traced forwards until the cranial limit of the first primary pharyngeal pouch is reached. Here there is a more abrupt diminution in width (text-fig. 12) and then a tolerably rapid tapering into the attenuated

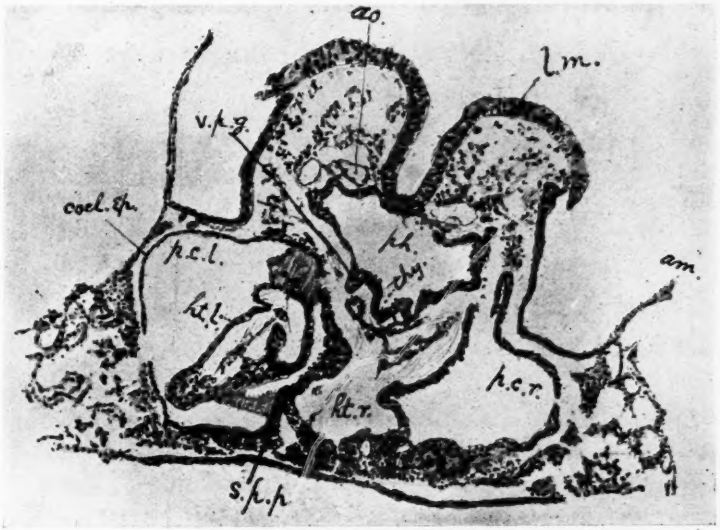

FIG. 6.—Section 140 of embryo "H 3."

blind extremity of the gut, still retaining its dorso-ventrally compressed character. This tapering terminal segment extends in a cranial direction for several sections beyond the ascertainable anterior limit of the oral sinus. No such marked ventral flexion of the narrow terminal segment of the gut as that seen in embryo "Klb" is recognisable. At a distance of 5 sections from its cranial limit, however, the contact which has up to that point been maintained between the dorsal wall of the pharynx and the medullary plate suddenly disappears. This separation corresponds with the now rapidly shallowing character of the medullary groove, as it is traced in the rostral direction. There is no recognisable trace of any Seessel's pouch.

I have made a rough wax-plate reconstruction of the entire pharynx,

but unfortunately certain dislocations of structure detract from its value for purposes of publication. In most respects, however, it is reliable enough, and it brings into prominence the tolerably close similarity in various features between embryo "H 3" and embryo "Klb" in respect of the pharynx.

Throughout nearly its entire length the ventral pharyngeal wall is depressed into a median V-shaped furrow. On the exterior of the model this expresses itself in the ventrally keeled appearance which the pharynx

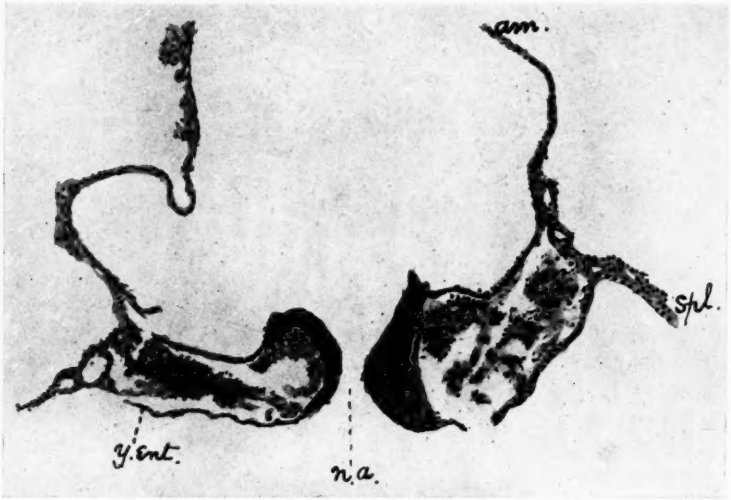

FIG. 7.—Section 76 of embryo "H 3."

thus presents. Though present throughout practically its entire length, the keel-like prominence varies in its degree of salience at different levels. It is already visible even in the region of the "primary pharyngeal membrane." Caudally from the level of the oral sinus it becomes accentuated where it overlies the paired pericardial cavities (text-fig. 12). But it is recognisable even where the dorsal pericardial wall is perfectly level. Nevertheless, text-fig. 18 inevitably suggests that this keel-like form of the early ventral pharyngeal wall is somehow a result of the bilateral constitution of the head region, as are the paired pericardial cavities themselves.

In the reconstruction model two maxima are apparent for the keeled ventral pharyngeal wall. One of these (text-fig. 6) appears to coincide with that in embryo "Klb" in the region between the first and second

pharyngeal pouches, which Grosser has determined as the thyreoid rudiment (6).

The second maximal development of the median ventral pharyngeal keel lies further forward (*cf.* text-figs. 12 and 18), in the region opposite the anterior end of the first pharyngeal pouch, and it is this accentuated portion of the keel which seems related to the imperfect interpericardial septum seen in these text-figures. In succeeding sections (proceeding in a caudal direction) there is a diminution of prominence of the ventral keel until it somewhat abruptly develops the second or thyreoid prominence seen in text-fig. 6. This then continues in a caudal direction until it merges in the median cranial boundary of the yolk-sac opening ("Darmpforte"). It thus appears that the thyreoid rudiment, though perhaps tolerably definitely localised in the cranial direction, has at the present stage no definite caudal limit.

There is seen on each side of the thyreoid rudiment in text-fig. 6, a "ventral pharyngeal groove," in Grosser's sense (*cf.* (6), pp. 274–75). This, however, begins more abruptly and perhaps more caudally than in embryo "Klb." It makes its appearance in the same section (142) which shows the first trace of the definite thyreoid rudiment. This is the eighth section behind the cranial limit of the first pharyngeal pouch. It may be noted that this bilateral "ventral pharyngeal groove," appearing as it does very abruptly, shows no sign of being continued from the ventral aspect of the first pharyngeal pouch, as described by Grosser in embryo "Klb." Further, it is more sharply defined, is of less cranio-caudal extent, and is somewhat more medial in position than would appear to have been the case in the latter embryo.

The first primary pharyngeal pouch is first met with in section 150 (text-fig. 12), in the form of an abrupt lateral extension from the side of the pharynx, exactly as in embryo "Klb" (Grosser's figs. 1 and 2 (6), and in Keibel-Mall (1), figs. 314–5). The latter dilatation of the pharynx thus arising, is continued caudally, showing no definite limit in this direction. It does not exhibit the pronounced and progressive diminution in its dorso-ventral dimension visible in Grosser's model, but there is a slight indication of expansion in the region corresponding to the "second pharyngeal pouch" of embryo "Klb," as shown in that model.

The dorsal wall of the pharynx is bulged towards its lumen along three longitudinal zones, corresponding respectively to the grooved medullary plate medially, and the two dorsal aortæ laterally. Grosser's description seems to imply that dorsal aortic impressions on the dorsal pharyngeal wall were absent in embryo "Klb"; but Keibel and Elze's fig. 5*a*, p. 19 (2), shows them quite definitely.

It has already been stated that, from a point 5 sections behind the anterior limit of the pharynx, the dorsal wall of the pharynx is in close apposition with the grooved medullary plate. This contact determines the median of the three longitudinal prominences which are evident along the dorsal wall of the pharynx. The entoderm covering this median prominence is that of the chorda-plate (*cf.* text-figs. 6, 14, etc.), but it is hardly, if at all, distinguishable from the rest of the entoderm at this stage. In the serial sections there are some ruptures of the continuity of the pharyngeal

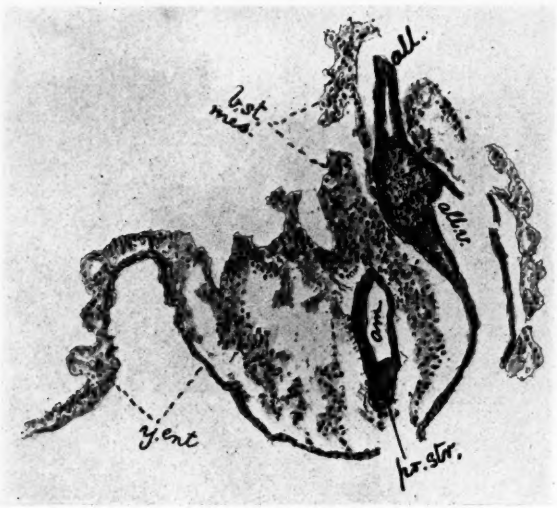

FIG. 8.—Section 29 of embryo "H 3."

entoderm, but this chorda-entoderm has very generally preserved its intimate relation to the medullary plate, which has afforded it a firm support. There is as yet no closed-in hind-gut. This condition is to be correlated with the absence of any true caudal prominence and the non-flexed condition of the entire primitive-streak region. Underlying the extreme hinder end of the latter, the cavity of the yolk-sac is prolonged, unilaterally, in a dorsal direction on the right side, into an asymmetrically placed *dorsal enteric groove*. Posteriorly (text-figs. 8 and 9), this groove leads into the somewhat dilated proximal portion or vestibule of the allantoic duct. This turns dorsally (text-fig. 9), and rapidly narrows into a canal of practically uniform fine calibre, being carried at first forwards into the cranially reflexed body-stalk.

The more medial wall of the asymmetrically placed dorsal enteric groove of the yolk-sac aforesaid exhibits, close to the proximal end of the allantoic vestibule, a well-marked depression which is closed by the thick cloacal membrane already referred to.

Allantoic Duct.

The proximal portion or vestibule of the allantoic duct has already been referred to, as also its continuation into a narrow canal of uniform calibre

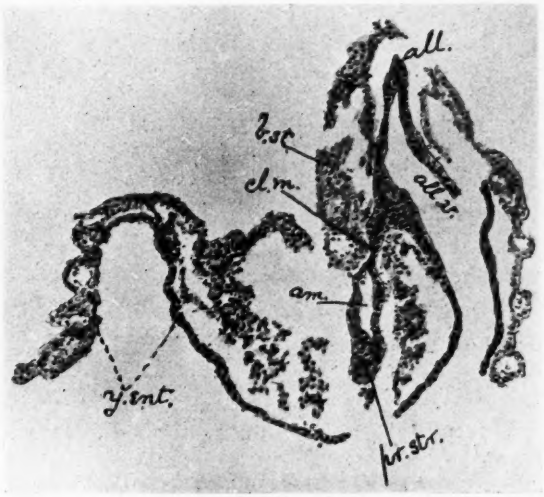

FIG. 9.—Section 28 of embryo "H 3."

prolonged into the reflexed body-stalk. After passing in a cranio-dorsal direction for some considerable distance (0·25 mm.), it bends further dorsally and then finally in the caudal direction and is now very slightly more attenuated. At a further distance of about 0·15 from its latest flexure, it now rather rapidly increases in size, and ends by expanding into a distinct vesicle. Throughout its entire tubular portion, it is lined by relatively thick cubical entoderm. At its expansion, this quite abruptly passes into very thin entodermal epithelium with which the terminal vesicle is lined. The maximum diameter of the lumen of the vesicular expansion is about eight times that of the tubular allantoic canal. Eternod has noted that the allantoic cord of his 1·3 mm. embryo had "no appreciable vesicular enlargement." A distance of 14 sections, or 0·14 mm., intervenes between

the commencement of the dilatation and the terminal fundus of the vesicle. The total length of the allantois, exclusive of what I have termed the allantoic vestibule, but including the terminal vesicle and allowing for the flexure of the canal, is over 0·6 mm. It may be said to follow a U-shaped course, the concavity of the U looking in the caudal direction.

Pericardium.

The pericardium lies chiefly ventral to the pharynx, but it extends for a distance of about 0·05 mm. in front of the cranial limit of the latter.

It consists of paired cavities which are in actual communication with one another for a distance of only 9 sections, whilst it is extremely probable

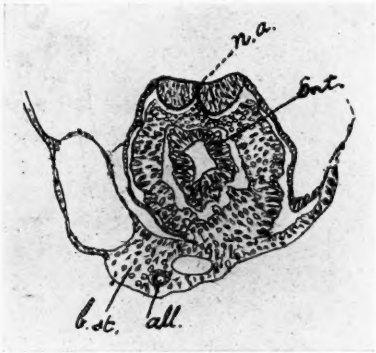

FIG. 10.—Section 128 of embryo "H 98."

that in the case of the three more cranial of these sections the communication is artificial and due to rupture of a delicate septum (*cf.* text-fig. 12).

The separation, partial or total, of the two pericardial cavities is effected differently in different regions of their extent.

Cranially and for a distance backwards of 15 sections (sections 152–137) there exists a genuine *septum proprium interpericardiacum* which is approximately median in position. In no one section does this appear as wholly complete, but there is little doubt that it was actually complete in its most cranial portion, as already indicated (text-fig. 12). As it is traced caudally this *septum proprium* becomes less and less complete (text-fig. 14), and gradually undergoes reduction (text-fig. 6) to the condition of a mere vestigial ridge of the ventral pericardial wall.

But already, considerably in front of the plane at which there is any marked reduction of the septum, the appearance of the heart rudiments,

with their dorsal and ventral mesocardial connexions (*cf.* text-figs. 14 and 6), effects the complete temporary separation of the more caudal regions of the two pericardial cavities.

These now, as they are traced further in the caudal direction, diverge gradually (text-fig. 15, right side) more and more from one another and are continued as the parietal (pleuropericardial) recesses.

The parietal recesses end blindly without establishing any communication with any other cœlomic cavity such as occurs later, *e.g.* in Mall's embryo, No. 391 (Dandy (7), pl. ii. fig. 11).

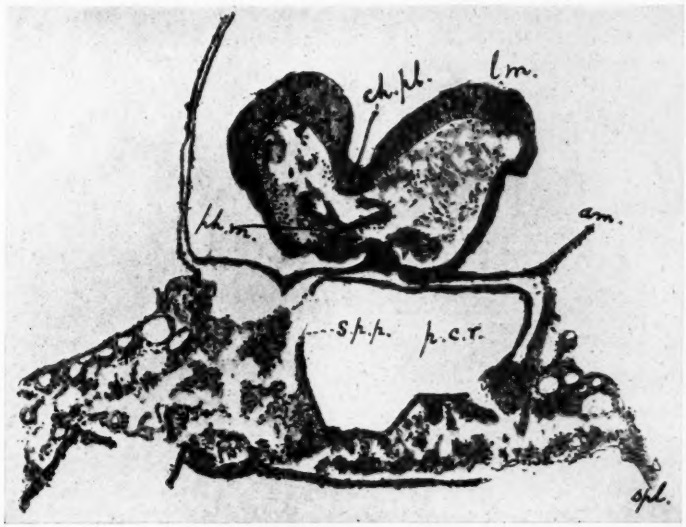

FIG. 11.—Section 155 of embryo "H 3."

Their lumina are only traceable for a distance of about 8 sections behind the termination of the crescentic curve of the cephalic medullary plate, or for a distance of about 12 sections behind the present posterior limit of the foregut (cranial margin of the "Darmpforte").

The paired pericardial cavities are lined throughout by a definite layer of cœlomic mesothelium, which in many of the sections has shrunk away to some extent from the mesoderm surrounding it (text-figs. 16 and 17).

The most cranial portions of the right and left pericardial cavities which are unoccupied by and wholly in front of the heart, occupy a position in the thick, plate-like mass of mesoderm uniting amnion and yolk-sac (*cf.* text-figs. 11, 12, and 16). The dorsoventral thickness of this mesodermal

mass is maintained throughout at about 0·3 mm. In the cranial direction, it merges in an accumulation of loose vascular mesoderm which lies in the angle between yolk-sac and amnion, supporting, dorsally, the cephalic fold of the latter, and continuous, ventrally, with the vascular mesoderm of the yolk-sac.

The presence of this mesodermal mass occasions a slight bulging ventral to the head of the embryo between amnion and yolk-sac (*cf.* text-figs. 2 and 3). This mesodermal mass may appropriately be styled the "pericardial

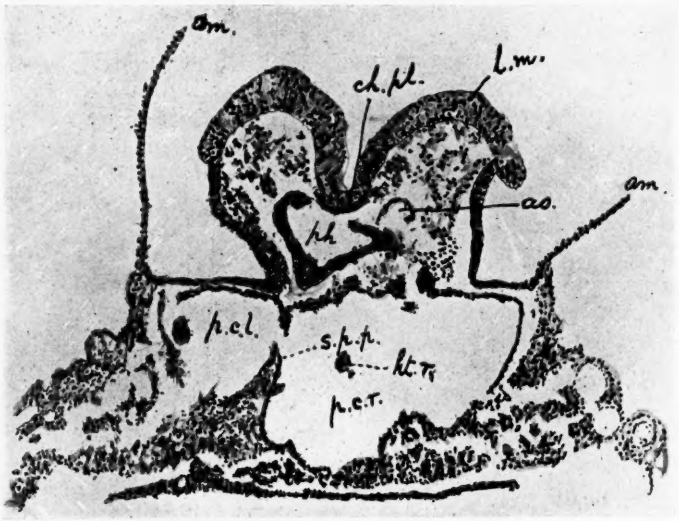

Fig. 12.—Section 150 of embryo "H 3."

plate," inasmuch as it soon gives place, and probably with great rapidity at this juncture, to a bulging pericardium as found in such a closely succeeding stage of development as that represented by embryo "H 98," *v. infra*, or as in Mall's embryo No. 391, F. T. Lewis' reconstruction, fig. 232, Keibel and Mall, vol. 2.

In the present case of embryo "H3" the paired pericardial cavities have already appeared in this pericardial plate (text-figs. 16 and 17), but they have not yet so completely excavated it as to form a bulbous pericardial protrusion anteriorly, as is the case in the succeeding stage.

The pericardial cavity is first met with in the serial sections at a plane lying 5 sections caudally to that of the anterior end of the medullary plate. Here (text-fig. 16) the cœlomic mesothelium lining the fore end of the right

pericardial cavity is first encountered. That the right cavity appears as much as 12 sections before the left (text-fig. 17) is largely, but perhaps not wholly, to be accounted for by the obliquity of the sectional plane, which is considerable.

As the serial sections are traced in the caudal direction, the pericardial cavities are found to expand so as to occupy the place of the thick mesoderm of the "pericardial plate," and they gradually supplant that tissue, the interval between the amniotic and yolk-sacs remaining practically unaltered (text-fig. 14).

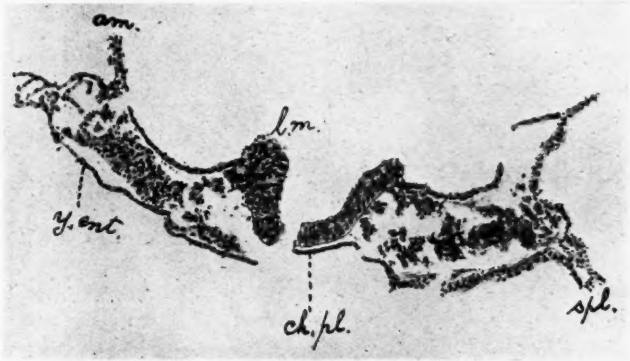

FIG. 13.—Section 81 of embryo "H 3."

Heart.

The heart itself is still almost completely duplex as regards not only its endothelial but also its myo-epicardial components. The duplicity of the latter may be recognised from a comparison of text-figs. 6 and 14. Text-fig. 6 shows portions of both right and left heart-tubes (myo-epicardial). Text-fig. 14 shows only the right heart. The plane of the latter section lies quite in front of the looped arterial end of the left heart, which is cut through in the section shown in text-fig. 6. To establish the connexions of this looped arterial left heart one must pass caudally from the plane of the last-named text-figure.

The marked dissimilarity of the right and left hearts in that figure is due mainly to the obliquity of the plane of section already referred to. It is somewhat difficult to state accurately the extent of this obliquity, but it may be indicated by the statement that the cranial limit of the first primary pharyngeal pouch on the right side lies some 8 or 9 sections in front of the corresponding point on the left. Were it not for this

obliquity the right and left heart-tubes would appear tolerably symmetrically arranged, though both of them already show a marked degree of individual flexure. The relations of each heart-tube to the interpericardial septum may be easily recognised in the text-figs. 6 and 14. It is evident that each heart-tube, in so far as it is separate, occupies its own pericardial cavity.

I have not yet been able to undertake a plastic reconstruction of this highly interesting state in cardiac development. This I hope to see carried

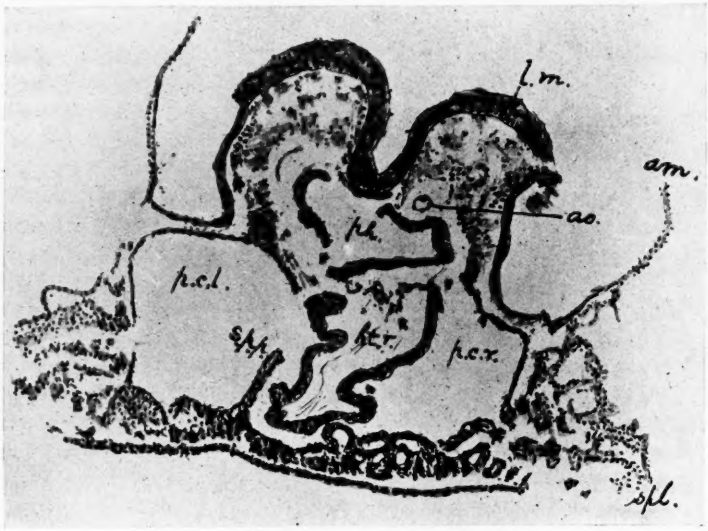

Fig. 14.—Section 144 of embryo "H 3."

out later on, although I fear that the degree of accuracy attainable will only be approximate. The section series is complete and quite intelligible, but there are histological imperfections which may be troublesome. This will be more especially the case with the endothelial heart-tube and the aortic arch system.

The arrangement of the latter I have not been able thus far to clear up satisfactorily from mere examination of the section series. So far as my observations go at present, I am disposed to regard the connexions between the arterial heart-tubes and the dorsal aortæ as still of a more or less plexiform character. Perhaps this relationship would also best explain the condition met with by Eternod in his 1·3 mm. embryo. And I can well

imagine the cardiac condition I find in embryo "H 3" to be immediately preceded by some such duplex tubular cardiac condition as that figured by Eternod in that interesting specimen. In any case, it is clear to me that there are several highly interesting pages of the history of early human cardiac development which are yet unwritten.

It is clear from the conditions met with in embryo "H 3" that the ordinarily accepted account of the origin of the single pericardium and heart in human development will not hold good without considerable modification. Thus Tandler, in Keibel and Mall's *Manual* (English edition, vol. 2),

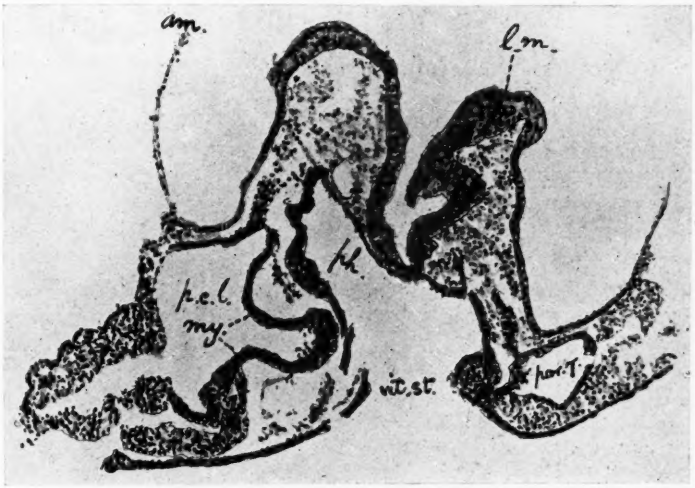

FIG. 15.—Section 127 of embryo "H 3."

says:—"On the closure of the fore-gut ventrally the hitherto symmetrical pleuropericardial cavities come together anteriorly and fuse in this region, the median partition between them, the *mesocardium anterius*, disappearing, while the *mesocardium posterius* persists for some time longer. The closely approximated but not yet fused endothelial tubes are now surrounded by a continuous *myo-epicardial mantle* (Mollier). Finally, the two endothelial tubes come into contact, their partition wall disappears, and the unpaired heart cylinder is formed from the paired heart-tubes. This stage of the development of the heart occurs in the Krömer-Pfannenstiel embryo 'Klb,' etc. etc."

The final result here referred to as manifest in embryo "Klb" may be quite correctly described, but the hypothetical preliminary phases leading

up to it are in all probability neither so simple nor so direct as Tandler represents them.

The fusion of the right and left pericardial cavities is, as we have seen, for a time incomplete anteriorly, and the imperfect septum separating them is not a "mesocardium" at all in the ordinary sense, but an interpericardial septum of mesoderm, quite independent of the heart-tubes themselves. Further, there occurs, prior to the state of single and continuous myo-epicardial mantle, a stage of an at least nearly complete duplex heart in which both right and left hearts possess myo-epicardial mantles which are,

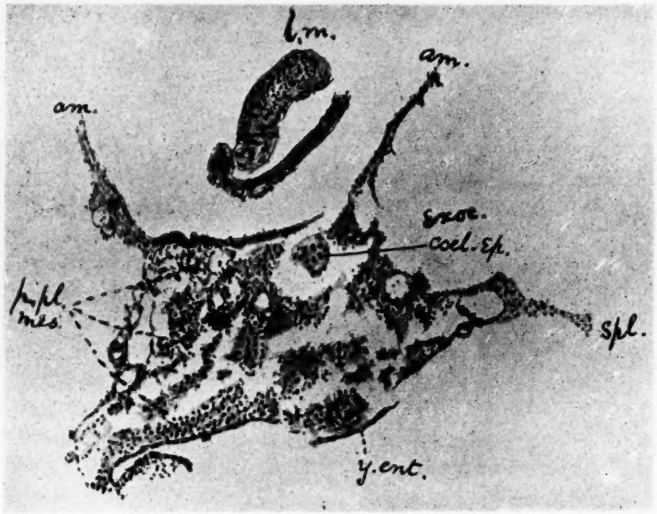

Fig. 16.—Section 165 of embryo "H 3."

at least throughout the greater part of their extent, independent of one another, and which cannot be regarded as mere semitubular elements completing a simple median heart-tube by their coalescence.

I may say here that through the courtesy of Professor J. P. Hill, F.R.S., I have had the opportunity of looking through a superb section-series of an embryo of Perameles in which the stage of cardiac development—evident with diagrammatic clearness—is obviously essentially identical with that which obtains in my embryo "H 3."

The condition in Perameles clearly shows that fore-gut closure in a mammalian embryo does not of itself at once determine median fusion of the primitively paired heart-tubes, for in this mammalian embryo one

finds a completely closed fore-gut very greatly expanded in the transverse direction, and, attached to its floor but widely separated from one another, there are seen independent right and left myo-epicardial tubes. These appear to be of essentially similar character to those of embryo " H 3," and, like them, each shows a definite and more or less symmetrical (in Perameles apparently quite symmetrical) primary flexure, definitely marking the venous and arterial subdivisions of the tube.

No further discussion of either cardiac or vascular systems can be

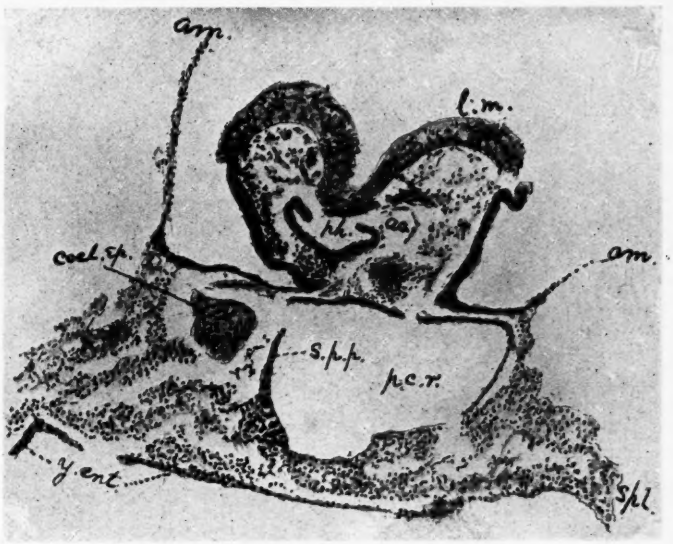

FIG. 17.—Section 153 of embryo " H 3."

undertaken on the present occasion. Many details of the vascular arrangements have not yet been ascertained with sufficient precision.

It may be stated that the vascular network in the wall of the yolk-sac is not only well established, but many of its channels show clear lumina with a definite endothelial lining.

Relative Position of Embryo " H 3" in the Human Embryonic Series.

The relative position, in a " Normentafel " of human embryonic development, to be assigned to embryo " H 3," has already been discussed in an earlier section of this paper. I place it in the interval between stages 2 and 3 of Keibel and Elze's *Normentafel* (2).

Although His' embryo "E" (No. 1 of his *Normentafel* (4)) is only known to us by its external characters, I believe that, notwithstanding its greater length, it offers the nearest parallel to "H 3." Both of these embryos I believe to be slightly more advanced than Eternod's "No. 7 Vuill." of 1·3 mm. length.

I have attempted to summarise the characteristics of embryo "H 3" on the general lines of the paradigm of Keibel and Elze's *Normentafel*, with a few modifications, so that the corresponding characters of various known

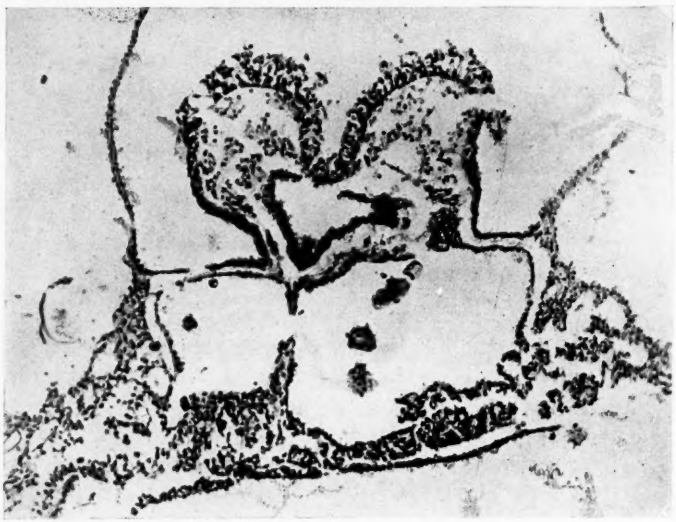

FIG. 18.—Section 149 of embryo "H 3."

embryos may be readily compared. That "H 3" is distinctly in advance of stage 2 of the *Normentafel* (Spee's embryo "Gle") is at once evident on comparison of the figures and descriptions. In particular the medullary plate and the pericardium and heart in "H 3" show a marked advance on the earlier stage.

The more outstanding characters which seem to differentiate "H 3," as earlier, from embryo "Klb," representing stage 3 of the *Normentafel*, are the following:—

1. In "H 3" the embryonic length, *as interpreted in the body of this paper*, is slightly less than that of "Klb."

2. In the former embryo no brain subdivisions were apparent in the otherwise well-marked cephalic medullary plate. On the other hand, the

brain region seems rather more prominent in "H 3" (fig. 2, Pl. I.) than in the published figures of "Klb."

3. The neurenteric aperture was widely patent, and was both relatively and absolutely closer to the head region in "H 3" than in "Klb."

4. In embryo "H 3" there was no hind-gut. On the other hand, the fore-gut, both in its dimensions and its degree of differentiation, differed only slightly from that of "Klb."

5. The chorda rudiment is in a much more backward stage in "H 3." Hardly any indication of it is visible, even in the form of a chorda-plate.

6. The somites, although not quite conclusively determined in "H 3," were certainly fewer (not more than three) in number.

7. The pericardium in "H 3" is still in the condition of bilaterally paired and nearly symmetrical cavities, separated by a *septum proprium interpericardiacum.*

The extent of the intercommunication between the two pericardial cavities is very limited.

8. The heart of "H 3" is still largely duplex, consisting of right and left myo-epicardial mantles.

Summary of Characters of Embryo "H 3."

Designation.—Human embryo "H 3" (Hdr). Collection J. T. Wilson.

Dimensions.—Chorionic vesicle 6·4 × 5·7 × 5 mm., ex. villi.

„ „ 8·5 × 5 „ incl. „

Length, amniotic sac 1·78 mm., yielding 151 sections.

„ embryonic region 1·64 mm., yielding 143 sections.

„ yolk-sac (distorted) 2·26 mm.

Depth, yolk-sac (dorsoventrally) 1·66 mm.

Length (cranio-caudally) of cephalic medullary plate, estimated as to the caudal limit of its prominent fold, 0·6 mm. ± (plus or minus).

Age.—Period elapsed since beginning of last menstruation to commencement of abortion, 40 days. Period since end of last menstruation, 36 days. Period elapsed since due date of lapsed menstruation, 12 days. Estimated age of embryo, 18–21 days. No conjugal history. Menstrual history as above.

Body Form.—No dorsal bend of embryonic body.

Primitive-streak region (= tail end) deeply furrowed, and forming only a very slight angle with the body proper. No tail-prominence other than caudal cushions bordering the furrow of the primitive-streak region.

Head end of brain-plate flexed ventrally over a pericardial-plate-prominence, which is already visible.

Primitive-Streak Region. — Neurenteric canal still widely patent Primitive-streak region tolerably lengthy (0·47 mm. in the section series) and deeply furrowed, and bordered by elongated, cushion-like caudal swellings.

Entire primitive-streak region still appears as the nearly direct caudal continuation of the embryonic body proper. Cloacal membrane posteriorly.

Mesodermal Segments.—Somites not visible on external examination; certainly fewer than five pairs, probably not more than two pairs, and not less than two.

Chorda.—Chorda entirely absent as such. Median strip of entoderm forming chorda-plate only recognisable with any degree of certainty just in front of the neurenteric aperture. But probably also in head region.

Nervous System.—Medullary plate expanded in front to form a brain-plate elevated laterally into prominent crescentic folds and flexed ventrally at its anterior end. Medullary groove well formed throughout but nowhere closed. No clear evidence of intrinsic brain segmentation. No traces of commencing formation of eye, ear, or nose.

Hypophysis.—No indication of hypophysis.

Mouth Cavity.—Very faint indication of oral sinus. Primary pharyngeal membrane shows abundant mesoderm between ectoderm and entoderm.

Digestive Tract.—Fore-gut ends blindly at cranial end. Consists solely of wide pharynx. Extends for 30 sections (0·3 mm.) in front of "Darmpforte." Hind-gut not yet closed in. A proximal dilatation or "allantoic vestibule" at root of allantoic duct opens widely into a unilateral dorsal groove of the yolk-sac, or "dorsal enteric groove," whose medial wall exhibits a well-marked depression closed by a cloacal membrane.

Pharyngeal Derivatives.—First primary pharyngeal pouch is differentiated, but is separated from the ectoderm of the head by thick layer of mesoderm. There is a general ventral median groove of the pharyngeal wall, whose maximal point of depression answers to the median thyreoid rudiment. "Ventral pharyngeal grooves" (paramedian) are also present. There is a possible faint indication of the appearance of a second primary pharyngeal pouch.

Urogenital System.—No indication of any urogenital apparatus.

Heart, Pericardium, and Vascular System.—Heart largely duplex; right and left myo-epicardial mantles occupy paired pericardial cavities, which are imperfectly separated by an incomplete *septum proprium interpericardiacum.* Right and left epimyocardial hearts each exhibit subdivision into venous and arterial segments. Paired dorsal aortæ.

Blood-vessels of yolk-sac contain corpuscles, but many show clear lumina lined by endothelium.

Amnion.—Amniotic sac extends for a distance of 8 sections in front of anterior end of head. It tapers at its hinder end, first gradually, then abruptly, into a narrow-pointed recess floored by the continuation of the primitive streak. The cloacal membranous connexion with the ectoderm lies at the right dorsolateral wall of this recess, very nearly at its apex. Mesoderm of the body-stalk extends like a hood over the hinder third of the amnion, and even in front of the body-stalk, the mesoderm of the amnion is thickened.

Allantois.—The allantoic duct opens by a dilated "allantoic vestibule" into a "dorsal enteric groove."

Sinuous in its course, it ends in a definite thin-walled, terminal vesicle. The total length of the canal, including the vesicle, is about 0·6 mm.

Second Embryo "H 98."[1]

For the second of my specimens, to be referred to as "H 98," I am indebted to the kindness of Dr F. P. Sandes, who obtained it as the result of abortion in a patient who had exceeded her menstrual period by 10 days.

Technique.

Dr Sandes brought the perfectly fresh and intact specimen direct to my laboratory, where it was at once placed in isotonic 10 per cent. solution of formalin. After fixation in this solution the specimen was transferred to alcohol. After complete dehydration, it was cleared *en bloc* in cedar oil, when the embryo in its interior became clearly discernible.

The chorionic vesicle was then carefully opened up under the stereo-binocular microscope, and the embryo, with body-stalk, amnion, and yolk-sac, was isolated from the greater part of the chorion. Micrometer measurements were made of the various dimensions of the embryo, etc., and the specimen was subjected to very careful and prolonged examination under the stereo-binocular microscope. It was also repeatedly photographed. On completion of the examination of the specimen *in toto*, it was double-embedded in cedar-oil-celloidin and paraffin, cut in faultless series of 10 μ sections transversely to its long axis, in caudo-cranial succession, mounted on albuminised slides, and double-stained in Benda's hæmatoxylin, followed by eosin. The quality of the sectional series thus obtained is exceptionally good for early human embryonic material. A rent in the right wall of the

[1] A lantern demonstration of slides of this embryo was given before the Anatomy Section of the International Medical Congress at its meeting in London in August 1913.

yolk-sac is visible in the sections, but this must have occurred prior to fixation, since there is a small collection of effused blood adherent to one area of the interior of the yolk-sac wall.

The sections being cut in caudo-cranial succession and mounted with their latest cut surfaces downwards, it will be evident that when the sections are looked at with the dorsal aspect away from the observer, the right embryonic surface is to his right, and the left to his left. This relationship is preserved in the photomicrographs and drawings of the sections.

It should be noticed that the sections, though cut in caudo-cranial succession, are not numbered in this order as they are in "H 3." The numbers of the sections in "H 98" run *cranio-caudally.*

Chorionic Vesicle of "H 98."

The chorionic vesicle of "H 98" (stereographic fig. 3, Pl. II.) was somewhat oval and flattened, and whilst still in the formalin fixative, it measured $6{\cdot}6 \times 5{\cdot}3 \times 4$ mm., exclusive of the villi. If the villi be included in the measurements, the dimensions were $9 \times 8 \times 5$ mm.

The chorionic wall was more or less villous throughout, except over part of one of the polar areas. As is so frequently the case with vesicles of approximately the same size, the villi were more luxuriantly developed around the equatorial zone of the flattened vesicle. As is also usual, the comparatively bald polar area of the vesicle was antembryonic.

The stereographic fig. 3, Pl. II., shows the chorionic vesicle, translucent in cedar oil, viewed by transmitted light. The embryo with its yolk-sac is visible in the interior.

When the chorionic vesicle was opened the interior was found to be filled with the normal "magma reticularis," clear and transparent and of semigelatinous consistency.

Appearance and Configuration of the Embryo and its Immediate Appendages.

As was to be expected from the circumstances of its reception and subsequent treatment, the condition of the embryo, etc., when isolated from the general chorion, appeared to be quite perfect. This judgment was borne out by the subsequent microscopical examination of the sectional series.

Apart from the one fact of its having been procured from a case of abortion (causation undetermined), there is no ground for regarding the embryo as in any way abnormal.

Figs. 4, 5, and 6, Pl. II. and III., illustrate the appearance presented by the embryo, etc., after isolation from the general chorion. In fig. 4, Pl. II., is reproduced a stereo-photograph obtained by enlarging the negatives taken with Zeiss' "*a* 3" paired objectives in the Braus-Drüner camera.

Fig. 5, Pl. III., represents a photomicrograph of the same at a magnification of 28 diameters; whilst fig. 6, Pl. III., represents a very careful drawing by Mr Herbert Beecroft, made with the aid of various photographs both stereoscopic and other.

Dimensions of Embryo "H 98."

Length from anterior limit of amniotic collar in front of head to posterior limit of body-stalk at chorionic attachment	1·8	mm.
Length of embryo, without body-stalk, from tip of anterior end of brain-plate to tip of tail, measured in a straight line	1·27	„
Greatest cranio-caudal length of *amniotic sac* .	1·38	„
Greatest cranio-caudal length of *yolk-sac* . .	1·46	„
Greatest dorsoventral extent of amnion in head region	0·86	„
Greatest dorsoventral extent of *yolk-sac* measured from line of reflection of amnion . . .	1·32	„

From the illustrations given, it will be seen that embryo "H 98" possessed 8 pairs of somites completely differentiated. My original notes of the examination of the specimen contain the statement that there are "probably 9 or 10 pairs of somites, of which the first pair appear to be very small."

The figures, *cf.* especially fig. 6, Pl. III., show indications of the existence of 10 pairs. But a plane reconstruction of the segmented mesoderm, since made, indicates that neither the first nor the last of the 10 segments is definitely segmented off from the axial mesoderm in front of, and behind, the somites. I can therefore only indicate the stage of somite formation by the statement that there are 8–10 pairs.

In Mall's embryo No. 391, reconstructed and described by Dandy (7), and also by F. T. Lewis (Keibel and Mall's *Manual*, vol. 2, fig. 232), there were 7 pairs of somites differentiated. Embryo "H 98" thus appears to be more advanced than the latter embryo, which is otherwise remarkably similar to it—to the extent of the appearance of one additional somite pair.

A feature of considerable interest in embryo "H 98" is its manifestation

of a well-marked, dorsally concave body-flexure (the "dorsal kink," "dorsal flexure," or "Knickung"). This was present in almost as high degree in the Mall embryo No. 391. In Dandy's opinion it was "partly natural and partly an exaggerated post-mortem condition." He remarks (*loc. cit.*) that "we should naturally expect a dorsal concavity due to the greater development of the structures in both the anterior and posterior regions of the embryo," and then proceeds to account for the supposed post-mortem accentuation of this character. I cannot help feeling that Dandy has been influenced in his attitude towards the question of this dorsal flexure or kink by the weight of Keibel's authority against considering it as a normal feature. I therefore desire specially to emphasise the following considerations in regard to the same feature as occurring in embryo "H 98":—

(*a*) The chorionic vesicle was obtained fresh and unopened; (*b*) it was fixed in 10 per cent. isotonic formalin, in accordance with the recommendations of Mann, in order to obviate or minimise to the utmost the tendency to tissue distortion; (*c*) the photographs taken through the walls of the cleared, but as yet unopened, chorionic vesicle already showed the well-marked dorsal flexure; (*d*) a consideration of the later photograph (fig. 4–6, Pl. II. and III.) will, I think, convince the unprejudiced observer that the existence of the developmental phase of the heart and pericardium shown in the photograph must almost necessarily have determined the temporarily erect attitude of the cranial end of the body, or, more strictly speaking, of the cephalic portion of the medullary plate. And it is this erect attitude of the latter which is the main (though not the only) factor in the production of the dorsal kink. The other factor, as indeed has been already implied by Dandy, is the elevation of the tail end. And this is in turn no doubt due to the ventral attachment of the embryonic stalk.

It is, of course, open to anyone to throw doubt upon the normal character of these and similar embryos. But it will not do to base such doubts solely upon the ground of the existence of the flexure, whose validity as a normal feature is *sub judice*. And it is to be noted that the Mall-Dandy embryo, although aborted, was from a case of traumatic abortion, in which there was therefore no reason to suspect any natural or inherent abnormality of the ovum.

With regard to the normal occurrence of the flexure in question in the human embryo, Keibel has repeatedly expressed himself as sceptical. In his latest utterance on this subject (*Manual*, vol. 1, 1910, pp. 66–7) he again records his judgment that the normal occurrence of a dorsal flexure in embryos of the stage of Kollmann's "von Bulle" embryo, or later, has been disproved. But he still leaves open the question of its occurrence as a normal feature in embryos of from 6 to 12 pairs of somites. At the

same time, he regards the evidence for its normal occurrence even in these stages as insufficiently based upon Eternod's 2·11 mm. embryo and Spee's embryo with 7 somites.

But, in the light of the condition met with in the Mall-Dandy embryo, and now again in my specimen "H 98," I submit that the normal existence of the dorsal flexure during stages of from 7 to 10 pairs of somites should be admitted. It is true that these two latest specimens are not by themselves wholly unimpeachable, being aborted specimens. But the traumatic character of the abortion in the one case, and the extreme care taken to avoid the possibility of distortion in the other, tend to establish the naturalness of the appearance. Each corroborates the other. And, in view of the facts as now before us, it is rather too much to ask us to set aside the positive evidence of flexure in a whole series of cases, viz. Spee's embryo with 7 somites, Eternod's embryo of 8 somites, the Unger embryo of Keibel himself with 9 somites, the Mall-Dandy embryo of 7 somites, and "H 98" with 8 to 10 somites, as each and all abnormal, whereas the fact of the matter now is that, so far as I am aware, *no* embryo of the stage of 7 to 10 somites has ever been recorded *without* the flexure in dispute.

Further, embryo "SR" No. 2, of His' *Normentafel*, is (I think unwarrantably) set aside by Keibel as probably abnormal, apparently solely on account of its possessing a dorsal flexure. Now, the dimensions of this embryo would tend to indicate that, although His does not show nor describe somites in this stage, the embryo must have possessed them. Embryo "SR," in fact, shows a tolerably close resemblance, so far as one can tell, to the stage of 7 to 12 somites, and may be confidently added to the list of embryos of this stage exhibiting the dorsal flexure.

Other features which may be noted in the figs. 4 to 6, Pl. II. and III., are (1) the differentiation of the cephalic portion of the medullary plate into fore-, mid-, and hind-brain regions. It is to be noted that what appears to be a primary cerebral flexure is at this stage intrinsic to the fore-brain region. The mid-brain shows no trace of flexure at all. One can recognise the same characteristic in the Mall-Dandy specimen and in Kollmann's "von Bulle" embryo; perhaps also, but more doubtfully, in the Kroemer-Pfannenstiel embryo "Klb." I have not seen attention drawn to this distinction, which is very striking in view of the fact that, later on, what we call the "primary cerebral flexure" lies in the region of the mid-brain.

(2) The contour of the fore-gut may be followed in the figs. 5 and 6 from its blind anterior extremity to its communication with the yolk-sac through the wide vitelline stalk. The posterior continuation of the hind-

gut from the caudal limit of the vitelline stalk into the tail region of the embryo may also be perceived. Incidentally, in connexion with the problem of the flexure, attention has been directed to the extremely prominent pericardial development. This condition represents a distinct advance on that seen in Mall's embryo No. 391, *cf.* especially F. T. Lewis' fig. 232 in the Keibel-Mall *Manual*, vol. 2. But it is an advance in the same direction as that of the progress from the stage of my "H 3" through that of embryo "Klb" to that of the Mall embryo No. 391. It is a progress which consists of a continuing process of excavation of what I have called the "pericardial plate" in embryo "H 3," and when that process of excavation has reached its limit, of a further process of bulbous expansion of the pericardial cavity.

I imagine that the condition seen in "H 98" must represent the maximum stage of this rapid expansion. When the stage of Kollmann's embryo "von Bulle" is reached, the development of the head has already overtaken the pericardium and the latter is forced ventrally by the now more or less overhanging head. The entire process seems to me a perfectly obvious and intelligible swaying in the balance of competing developmental processes. I do not even see that one is forced to believe that the equilibrium is always precisely similarly maintained at all corresponding movements in the otherwise perfectly normal course of development.

It is quite likely that another factor in the maintenance of developmental equilibrium in this region is the rate of amniotic expansion. We know perfectly well that, at least in later stages, the rate of growth and expansion of the amnion varies within tolerably wide limits without being in the least abnormal. I see little reason to deny that these may be quite normal variations in a similar sense, though of lesser degree, even at the early period now under consideration.

The carrying out of an adequate structural analysis of this embryo from the serial sections has been largely in suspense during my personal absence from Sydney. Ere I left I had done some work in the direction of reconstruction of the heart, but I do not propose now to enter upon the discussion of the sectional anatomy of this embryo. This will, I hope, form a portion of the subject-matter of Part II. of this contribution to our knowledge of early human embryos.

The sequel will also, I hope, contain a descriptive account of the third embryo of the series, viz. "H 86" in my list.

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EXPLANATION OF LETTERING OF TEXT-FIGURES.

(All sectional figures are reproduced at a magnification of 100 diameters.)

all.	allantois.
all.v.	allantoic vestibule.
am.	amnion.
ao.	dorsal aorta.
b.st.	body-stalk.
c.sw.	caudal prominences (caudal cushions).
ch.pl.	chorda-plate (?).
cl.m.	cloacal membrane.
cœl.ep.	cœlomic epithelium.
ent.	entoderm.
exoc.	exocœlom.
ht.l.	left heart-tube.
ht.r.	right heart-tube.
l.m.	medullary lamina.
mes.	mesoderm.
my.	myo-epicardial mantle.
n.a.	neurenteric aperture.
p.c.l.	left pericardial cœlom.
p.c.r.	right pericardial cœlom.
p.pl.	pericardial plate.
par.r.	parietal recess (pleuropericardial).
ph.	pharynx.
ph.m.	primary pharyngeal (oral) membrane.
pr.str.	primitive-streak tissue.
s.p.p.	septum proprium interpericardiacum.
spl.	splanchnopleure.
thy.	thyreoid rudiment (median).
v.p.g.	ventral pharyngeal groove (Grosser).
vit.st.	orifice of vitelline stalk ("Darmpforte").
y.s.	yolk-sac.
yk.ent.	yolk entoderm.

EXPLANATION OF TEXT-FIG. 18.

Photomicrograph (× 100) of section No. 149 of human embryo "H 3," at the level of the cranial limit of the 1st right primary pharyngeal pouch.

The section is rather obliquely cut. It passes through the cephalic portion of the medullary plate, whose edges are well defined. In contact with the median ectoderm of the floor of the medullary groove may be seen the adherent strip of

pharyngeal entoderm which represents the chorda-plate. The pharynx shows its medio-ventral keel immediately dorsal and corresponding to the *septum proprium interpericardiacum* (see text). The latter nearly completely separates right and left pericardial chambers, which show a very definite cœlomic epithelial lining. The right chamber contains portions of tissue from tangential grazing of the cranial bulging of the right myo-epicardial tube. The dorsal aortæ are visible dorsal of the pharynx.

Note the entoderm lining the roof of the yolk-sac in the lower part of the figure, and the amnion on either side in the upper part.

EXPLANATION OF PLATES I.–III. FIGS. 1–6.

Plate I. Fig. 1.

Photomicrograph of chorionic vesicle of human embryo "H 3." × 7 (reduced from × 14).

Zeiss' 35 mm. micro-projection objective.

The photograph was taken after slight surface staining with hæmatoxylin and subsequent clearing of the entire vesicle in cedar oil.

Note the very slightly branched villi on the exterior of the vesicle. The embryo, with its more intimate appendages, amnion and yolk-sac, are visible in the interior. The yolk-sac is the larger crumpled sac mainly to the left of the embryo. The sharply defined clear outline of the more anterior portion of the amnion may be seen to the right and (in the figure) above the nearly vertically directed embryonic rudiment.

Plate I. Fig. 2.

Photomicrograph (× 15·5) of human embryo "H 3," with its amnion, yolk-sac, body-stalk, and a portion of its chorion, viewed from the right dorsolateral aspect.

Zeiss' 35 mm. micro-projection objective.

The somewhat collapsed and crumpled yolk-sac is seen in the lower part of the figure. The patch of chorion giving attachment to the embryo, etc., in the upper part of the figure presents its edge, for the most part, to the observer and shows no detail. Descending from this towards the embryo is the body-stalk and tail-half of the amnion. This latter appears as if separated from the anterior portion of the amnion by a deep crease of the membrane. The body-stalk is evidently directed dorsally and cranially from the caudal end of the embryonic rudiment. The medullary folds of the embryo are visible within the amnion anteriorly, and the leaf-like area traversed by the primitive streak posteriorly.

Plate II. Fig. 3.

Stereo-photomicrograph of chorionic vesicle of human embryo "H 98." The photograph was taken from the specimen in cedar oil by transmitted light, under the Braus-Drüner camera, Zeiss' stereo-objectives α°, magnification × 2·8.

The vesicle is translucent, and shows the embryo and yolk-sac in its interior.

PLATE II. FIG. 4.

Stereo-photomicrograph (× 16) of human embryo "H 98," with amnion, body-stalk, and yolk-sac. Enlarged from negative taken with Zeiss' stereo-objective a^2 at four diameters.

The specimen was photographed in cedar oil by transmitted light.

Compare with figs. 5 and 6, Pl. III.

The body-stalk is practically complete, although the portion of chorion which had been left in connexion with it became detached whilst in the cedar oil. The dark patches in the body-stalk represent the blood content of vessels.

The pericardium and heart form a prominent bulging mass ventrally to the head, which is, in consequence, erect in attitude.

The amnion and yolk-sac are both almost wholly free from folds, and there is no evidence of shrinkage.

PLATE III. FIG. 5.

Photomicrograph (× 28) of human embryo "H 98," with amnion, body-stalk, and yolk-sac.

See description of fig. 4 and text, and compare with figs. 4 and 6, Pl. II. and III.

PLATE III. FIG. 6.

Human embryo "H 98," with amnion, body-stalk, and yolk-sac.

Drawn from photographs and stereo-photographs by Mr Herbert Beecroft, Sydney.

See description of fig. 4 and text, and compare with figs. 4 and 5, Pl. II. and III.

REVIEW.

INNERE SEKRETION: IHRE PHYSIOLOGISCHE GRUNDLAGEN UND IHRE BEDEUTUNG FÜR DIE PATHOLOGIE. Professor A. BIEDL, Vienna. Second edition. Part I. pp. 534. 8 plates and 131 figures in text. Part II. pp. 692.

THE subject of "internal secretion" is one of the very highest importance, and the amount of research work which has been carried out recently in this one subject is enormous. So great is the output of work that it is impossible for the average reader to peruse all the original publications. A book which contains the essentials of these numerous papers is therefore very welcome, particularly when it has been compiled by so eminent an authority as Professor Biedl.

Part I. of the new edition, which we have had the pleasure of reading, differs considerably from the original work. The inclusion of the results of recent investigations necessitated an increase in the size of the book and the recasting of the whole. The book has, in fact, been practically rewritten.

The first volume deals with the parathyroids, thyroids, thymus, and includes a large section on the adrenal system. These various internal secretory organs are dealt with in turn in considerable detail. Their development, structure, and comparative morphology are described, and what is known concerning their physiological function is set out by condensed accounts of the numerous original researches dealing with this aspect of the subject. Experiments on the effect of complete and partial excision of these glands in various species of animals are quoted, and the views of different experimenters are included. The chemistry of the glands and their products also receives attention, though in this particular direction the available knowledge is not great.

After this review the pathological aspect of the subject is considered and the rôle of internal secretion in morbid processes is indicated. The results of feeding experiments with the several glands and the effects of grafting them in man and animals are given in detail.

It is a feature of the book that experimenters are quoted even when their results and views are divergent or directly contradictory. This is unavoidable in a subject where so much is uncertain and in which bedrock facts are few. But amid the mass of divergent views the reader is apt to become bewildered. It has been said that physiology always progresses, but that it often progresses sideways. Amid the numerous pathways set out before us here we are often unable to determine which is probably the true path of progress. We feel that the value of Professor Biedl's work would be enhanced if he had, after a critical summary of the conflicting experiments, indicated which pathway was the best to follow. It must not be thought that the book is devoid of criticism—far from it,—but we feel that there is not enough of it. Professor Biedl, who has devoted his life to this subject, could have supplied effective criticism even where he had not himself worked at the particular point in question.

As is unavoidable in a book of this size, a few mistakes are noticeable. Some of the chemical formulæ are inaccurate, and the nature of ergotoxine appears to have

been misunderstood. These errors are, however, few and small, and we cordially recommend the book to those interested in the fascinating subject of internal secretion. They will find in it brief accounts of nearly all the original work which has been done on the subject, and from these they will gain not only a knowledge of the subject as it stands to-day, but the possibilities of to-morrow, which may lure them on to further investigation.

The second and concluding volume of Professor Biedl's book has appeared recently. The first seventy pages are devoted to the completion of that section of the work dealing with the adrenal system, after which the remaining three hundred pages treat of the internal secretions of the intercarotic and coccygeal bodies, the pituitary body, the pineal gland, the generative organs, the pancreas, the alimentary canal, and the kidneys. The subject is dealt with in the same thorough manner as in the first volume, and very full references to original work are included. The mass of original papers which have been abstracted for our benefit in this work may be realised when it is pointed out that the index to the literature occupies over 250 pages.

It may be doubted whether the plan, which has been adopted, of reserving the references and index for the end of the second volume is the best possible. Both volumes must be to hand in order to obtain a reference to an original paper. We feel that literature references at the foot of each page would render the referring to original papers much easier, and that the general index might with advantage be duplicated in the first volume.

We feel sure that this book will meet with the great success which it deserves. If we take exception here and there to the manner of its compilation and to the lack of illuminating criticism, we must remember that Professor Biedl has given us exhaustive references, and that by referring to the original papers which he quotes we may form our own opinions.

P. P. L.

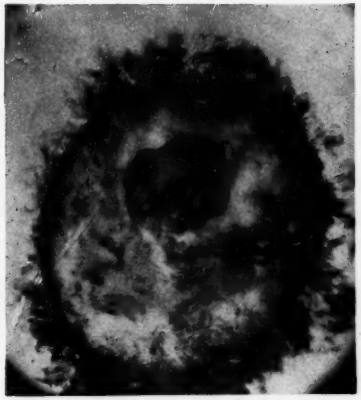

Fig. 1.

Fig. 2.

FIG. 1.—Chorionic vesicle of embryo "H 3." ×7.
FIG. 2.—Embryo of "H 3." ×15.

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Fig. 3.

Fig. 4.

FIG. 3.—Stereo-microphotograph of the chorionic vesicle of embryo "H 98."
FIG. 4.—Stereo-microphotograph of the embryo of "H 98."

Professor J. T. WILSON,

Fig. 6.

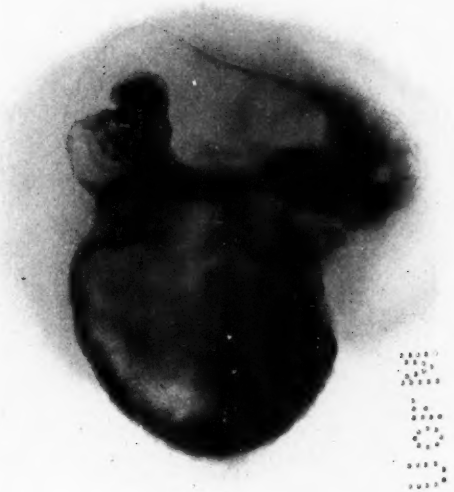

Fig. 5.

FIG. 5.—Microphotograph of the embryo of "H 98."

FIG. 6.—Composite drawing of embryo "H 98" made by Mr Beecroft from a series of photographs.